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NEW YORK, MAY, 1890.

THE example set by the Vanderbilt University in Tennessee is followed by the Case School of Applied Science in Cleveland, O., which offers a free course of instruction in road management to all who desire to avail themselves of it. The instruction will consist of lectures on Location and Construction of Roads; Keeping up and Repairing Roads; Ditching and Drainage; Road Making Machinery; Improvement of Surface, including the use of Gravel, Stone, Plank, etc.; Highway Structures, including Culverts and Bridges; Cost of Earth Work and Mechanical Structures; Highway Administration, and Highway Laws. For those who desire it, additional instruction will be given in the use of engineering instruments and in drawing, and lectures on special topics connected with road-making will be given by engineers of experience. The course will begin in February, 1891, and will continue about a month.

This seems to be a very practical attempt toward the solution of the road problem, and it is to be hoped that full advantage will be taken of the offer.

THE production of pig iron continues to increase, and the April report of the furnaces shows that, as compared with March 1st, there was an increase of four furnaces in blast, with an increase in capacity of about 7,700 tons per week. As compared with last year at the same time, there is an increase of 34 in the number of furnaces in blast and of 43,300 tons in the weekly capacity. The present production, we believe, is the largest on record, but does not seem to exceed the demand.

THE breakdown of one of the engines of the *City of Paris*, which came near producing very serious results to that steamer and its passengers, has not yet been explained. From the accounts received, it appears that the low-pressure cylinder gave away in some manner, and that one engine was practically destroyed, and the other engine seriously injured by flying pieces of metal. At the same time the outboard valves were left open and the connections so damaged that they could not be closed, and in consequence a large amount of water was admitted to the engine-room compartment. It was at first supposed that the bottom of the vessel had been damaged, but later accounts say that this was not the case. It is impossible to say what part of the machinery gave away first, but it appears that the connecting-rod continued to move up and down for some time after the break took place, and that the loose end of this heavy rod did a great part of the damage. Further accounts of the accident will be looked for with interest, and it is hoped that a full statement will be given.

FIRE-BRICK FIRE-BOXES FOR LOCOMOTIVES.

ON another page we publish some comments and plans of fire-boxes, without stay-bolts, which were presented at a meeting of the German Technical Railroad Union. One of these plans shows an old boiler which was rebuilt with a fire-brick fire-box, the original casing or outside shell of the fire-box being used for the new one. The attention of the skeptics—especially the Locomotive Editor of the *Railroad Gazette*—who have oppugned this form of fire-box, when it has been proposed, is called to the evidence given by Herr Bork, Locomotive Inspector of the Thuringian Railroad, with reference to the working of this experimental boiler. Seven years' experience with this engine and boiler showed, Herr Bork says:

> That the apprehension felt that the shocks experienced on the road in service might affect the durability of the boiler were unfounded. By the use of good materials, in the first place, long life was secured for the fire-box. The boiler steamed well, and *the radiation of heat from the fire-box was not greater than in an ordinary locomotive.* The tubes and tube-sheet kept in good condition, but the latter had to be renewed after about three years' service. The reason for this was that, owing to the very rapid formation of steam on the heating surface of the tubes nearest the tube-sheet, and the use of bad water, a considerable deposit formed on the lower part of the sheet.

This difficulty, it is thought, might have been anticipated as a consequence of the inclination of the tube-sheet, as shown in fig. 5, on page 221. There was no more difficulty *in keeping the tubes tight*, Herr Bork said, *than in any ordinary locomotive.* Another boiler, shown by figs. 7 and 8, page 222, has been designed by him to overcome the difficulty with the tube-sheet, which is placed vertically in the new design, and a man-hole is provided in the under side of the barrel of the boiler, immediately in front of the fire-box, for cleaning out any deposit which may accumulate at the back end.

In commenting on this plan another engineer says:

> The simplicity of construction of these boilers is so great that their first cost *will not be much more than half* that of the ordinary locomotive boilers, while the experience had with that already in service indicates that *the cost of maintenance also will not be over half.*
>
> With this arrangement *the boiler is a simple cylinder*, to which the fire-brick lined fire-box is attached at one end and the smoke-box at the other. The only flat surfaces are the tube-sheets, which are practically so bound together by the tubes that they require little additional bracing. Already such improvements have been made in manufacture that a boiler barrel can be made of a single plate, and it is believed that the longitudinal riveting even can be dispensed with and the boiler barrel made of a single piece, welding taking the place of the rivets.

As the shell of the fire-box is not subjected to internal pressure, it need not be made as strong as ordinary fire-boxes are, and it would be subjected to little or no corrosion. It need not, in fact, be made water-tight. There would be no stay-bolts, no crown-bars, no crown-sheets, side nor end plates, and no mud-rings, all of which give incessant trouble.

If these inferences are true, they are of the most momentous importance to those interested in railroads the world

over. The apathy with which the proposal to use such boilers has been received is remarkable, and the hostility to even a consideration of the plan, which has been manifested in many quarters, is most astonishing. The fire-box of a locomotive is the most expensive part to construct and maintain. If the first cost and subsequent cost of maintenance could be reduced *one-half*, and, at the same time, as Mr. Urquhart testified, if considerably less time is required to repair such fire-boxes, and consequently locomotives with them will do more service, the subject should be worthy of careful consideration and thorough investigation by railroad managers.

THE LOCATION OF HIGHWAY ROADS.

THE agitation for reform in our highway roads, to which reference has been made from time to time, has not been dropped by any means, but has been continued in various quarters. The law passed last year in New Jersey, authorizing systems of county roads, is on trial, and promises good results; already action under it has been taken in several counties, and this year some slight amendments have been secured, to remove objections made to its workings. In New York the Governor's yearly message commended the question to the Legislature, suggesting a system of State roads, and in several other States attention has been called to the matter in various ways. In Pennsylvania a commission was appointed last year to prepare a new road law, and its deliberations were assisted by a convention called by the State Board of Agriculture, at which representatives of various bodies were present.

The Engineers' Society of Western Pennsylvania has paid particular attention to the highway question, and its reports and proceedings contain much valuable matter bearing upon it. The efforts of that society have been wisely directed toward securing improvement in local road boards and in the State laws controlling them.

There is no longer in this country any question of great National or State roads extending over long distances. The need is of systems of good roads giving every one facilities for travel to the railroad station or wharf whence his freight may be started on its longer journey by rail or water, and from which he may haul such supplies as he needs. Good local roads, to repeat, are what is most needed, and no pains should be spared in impressing upon public opinion their necessity, and in making plain to all how great a tax their absence imposes upon the community. Until this is done, no permanent improvement can be hoped for.

It is not intended to take up in this article the discussion of methods of road-making or maintenance. Important as they are, there is a point which precedes them, and that is the proper and judicious location of roads, and this point, unfortunately, has been very much neglected.

Of course, in laying out a road, the needs of local traffic and the accommodation of the residents of a district must be carefully considered, but in too many cases these have been the only points taken into account, to the total disregard of all engineering considerations, and the result has been the construction of roads so radically bad in many respects that no amount of improvement in maintenance can make them such highways as will properly and economically serve their object. This must continue to be the case as long as the present district system, which is in operation in a number of States, continues without modification. The local authority—road board, town committee, selectmen, or whatever may be the title—may understand the needs of a neighborhood, but is much too likely to be influenced by considerations of temporary expediency, local influence or position, tax rates, and other matters of the kind, while its members very seldom know anything of engineering, and are generally altogether without a realizing sense of the heavy tax which a badly-located road levies upon all who use it. The results are found everywhere in highways run upon lines which no surveyor who understands his business would consider for a moment, and which may practically double the cost of hauling to market the products of an entire district. A few illustrations or practical applications may serve to make this plain.

The accompanying rough sketches show some locations of the kind referred to; they are made from memoranda jotted down in haste, and without any pretense at exactness, but it is believed that they will show sufficiently well examples of bad work of different kinds. Doubtless every engineer—indeed, every observant traveler—who has had occasion to journey much by highway, can recall many similar cases.

To particularize, fig. 1 shows a short section of a much-traveled road in Northern New Jersey. In this case a very sharp and annoying hill is interposed, which might be entirely avoided by a slight detour. The change in plan and

Fig. 1.

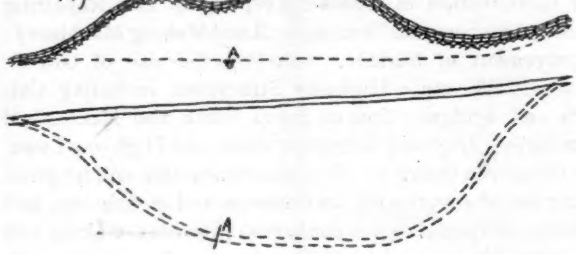
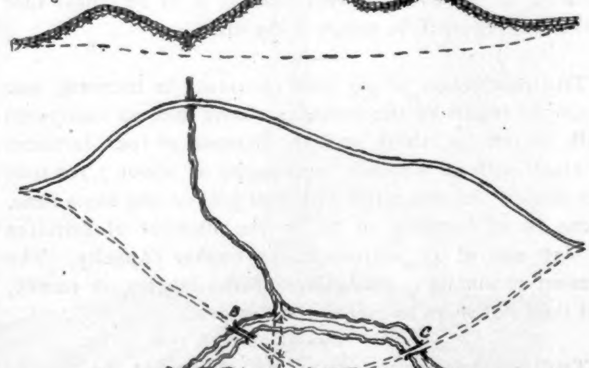


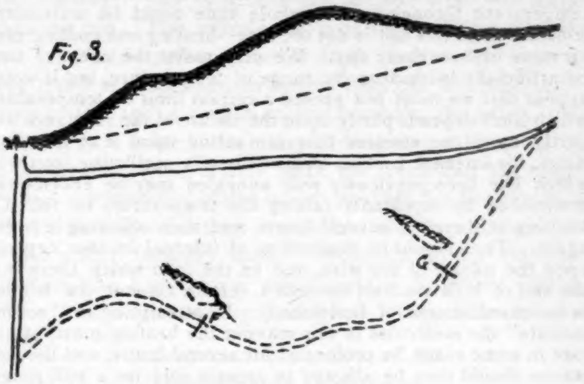
Fig. 2

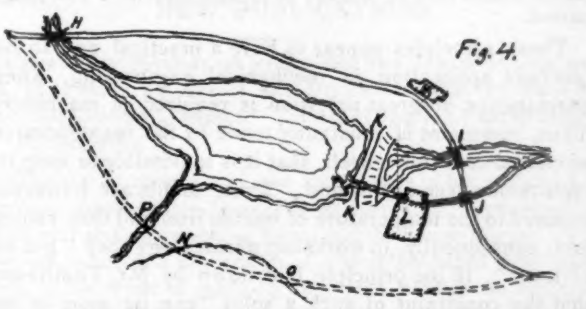


grade is indicated by the dotted lines, and would not be expensive, as the only work required, beyond ordinary road-making, would be the building of a small culvert at *A*, to pass the water flowing from a spring at the foot of the hill. Why the road should have been carried over instead of around the hill in the first place, it is very hard to see, especially as it is not an air-line by any means, and there are plenty of curves at other points.

Fig. 2 shows a section of road in New York, not far from the Hudson River, where the hills seem actually to have been sought, while an easy location and grade might have been secured, as shown by the dotted lines. In this case, perhaps, there is a little show of reason, since in its changed location the road would cross a small stream at *B* and again at *C*; but the cost of the bridges would be small, compared with the advantage gained, while they might be easily avoided by digging a ditch from *D* to *E*, the expense of which would be very slight indeed.

Both these cases are notable, as they both occur in long-settled and prosperous districts, where the general condition of the ways is above the average. Both are on old roads which have been in existence for more than a century, and it is certainly difficult to understand how they have been allowed to remain generation after generation,





when in each case the remedy was so plain. Inquiry developed the fact that changes had been suggested, but neighborhood conservatism had been too strong for the would-be innovators, and the "old road" had been kept in its old place.

Fig. 3 shows a very steep and ugly hill on a road of considerable traffic in the Catskill region. In this case there is a rise which could not be avoided, but the much easier and even grade shown by the dotted line in the profile could have been obtained by following the location shown by the dotted lines in the plan; nor would any heavy work be required, as the hill-side could be followed everywhere except at the points *F* and *G*, where a little cutting would be needed, as shown by the sketched cross-sections; but at neither point would this cutting extend for more than 25 or 30 ft., nor be of an expensive character.

In this case the road was of comparatively recent construction, and it appears that it had been laid out to follow the boundary line between two farms. A change had been suggested, but the objection was raised that it would leave Farmer *X* a small and badly-shaped lot on the "wrong side of the road." In other words, the desire of the Town Committee to oblige a neighbor has imposed upon all the community using the road a perpetual tax, which is, perhaps, not realized because it is not paid out in money, but which is none the less an actual and onerous one.

In fig. 4 is shown a location bad, not on account of the grade, but for other reasons. On the line chosen for the road at this point there are two bridges of about 40 ft. span over the stream at *H* and *I*, and one of 15 ft. over the tail-race at *J*, below the small mill at *L*; moreover, the bridge at *I* is just below the earth dam *K K*, which is liable to fail under the pressure of any unusually heavy spring freshet. On the location shown by the dotted lines there would have been only one bridge, of 15 ft. span, over the little stream at *P*, and no extra work, except a light cutting in the hill-side, from *N* to *O*, nowhere over a few feet deep. The cost would have been less and the road safer from damage.

This last case is taken from a New England State, and here common rumor assigned a disreputable motive as partly the cause for the bad location. One reason given was the position of the miller's house at *M*, but it was also freely said that the final choice was due to the expectation of at least a majority of the Selectmen that they could "make something" out of the bridge-letting. The worst feature of it was that this did not seem to be regarded as very unusual or very reprehensible, and to an inquirer, with deep confidence in that rural virtue of which we hear so much—in the city—this was somewhat of a shock.

Now it is not the intention to say that town officers are universally or generally corrupt; doubtless many are honest and willing to act for the best interest of the community, as they see it, but the best intentions do not give a man the knowledge necessary to lay out a road or the skill to see how a bad location can be avoided.

The moral of the instances given above is that under any system of proper and intelligent supervision such mistakes could not be made, or could not be perpetuated. A county engineer, if at all competent for his position, would see at once what the true interests of the district required; his object would be to provide the best road possible and not to preserve farm fences or old boundary lines, and under proper regulations he could have no corrupt interest to serve.

The new law in New Jersey, to which reference has been made, provides for the total or partial transfer of roads from the townships to the county, and for the employment of a county engineer as executive officer. A change strongly urged in Pennsylvania is the appointment of county engineers, with power of supervision over the local boards, and of a State Engineer who shall be a general adviser and arbitrator, much in the way in which the State Superintendent of Education now acts. Both plans have advantages which can readily be seen; the adoption of one of them seems essential to any real reform.

The whole matter is so bound up with questions of local taxation and with the widely prevailing and popular, but vicious, system of "working out" road taxes, that one of the first requisites is to educate upon this subject public opinion among the classes most directly interested. This can only be done by continued effort, and it is to be hoped that the associations which have undertaken it will be encouraged to persevere in their good work.

THE INSTABILITY OF SOLIDS.

It has often been observed that the form of castings is altered by changes in temperature. This is seen in the varying and warped shapes of malleable castings after

being annealed. Another instance of this kind, where the range of temperature to which the metal is exposed is not so great, is that of double disk throttle-valves used on locomotives. No matter how carefully these are ground, and how tight they are made when the engine is new, they nearly always leak after being exposed to steam for a few hours or days. If they are then reground they will remain tight. The same experience often occurs with tubes. They may be calked so as to be perfectly tight when the locomotive leaves the shop, but will leak after being in service a short time. If they are then recalked they will usually remain tight. The reason of this apparently is in the first case that the metal in cooling, after being cast is in a state of internal strain. On being heated to a temperature considerably less than the melting-point, this strain is relaxed and a change of form results. By repeatedly heating and cooling, and thus relaxing these strains, this internal strain assumes a condition of equilibrium and the form of the casting will then not be affected by further changes of temperature.

There are many illustrations in common experience of this action, as in the case of cast-iron car-wheels, which must always be annealed, because if they are not they are liable to break in service. A curious instance of this occurred in the experience of the writer. He had in his possession a ½-in. hardened steel cylindrical gauge which fitted *perfectly* into a ring of the usual form made for such gauges. This was kept in a morocco case lined with silk and plush, and kept in the editorial desk where no one had access to it but the writer. It was never used excepting to exhibit it as a curiosity, and was not used in that way more than perhaps half a dozen times in all. After resting quietly in the desk for somewhat less than a year, it was found that the plug or ring, or both, had in some way changed their dimensions so that the one would shake sensibly inside of the other. There is no doubt that they fitted each other at the beginning of the period named, as near perfectly as could be ascertained by the sense of feeling, and it is equally certain that they did not fit each other at the end of the time referred to. There is no probability that they were handled during that time by any one but the writer, or by some one in his presence, or that they were tampered with by any other person. Now what is the explanation ? There can be no doubt that metal exposed to high and then to low temperature changes both its form and dimensions, as in the case of locomotive tires, which will be somewhat smaller after being heated "cherry-red" and cooled. There is every reason to believe that much lower ranges of temperature will alter the form and dimensions of metal, which changes can be recognized only if we have sufficiently delicate means of measuring them, as we have in the case of a cylindrical gauge and its ring. In other words, the ordinary atmospheric changes of temperature affected the form of the ring or the dimensions of the plug, but to so small an extent that it could not be detected by any ordinary means of measurement. The great accuracy with which they were made to fit each other gave the means of discerning the change.

A writer, Mr. Herbert Tomlinson, in a recent number of *Nature*, in commenting on the permanent ascent of the zero-point of a mercurial thermometer, after prolonged heating to a high temperature, has given some interesting and valuable observations on this subject. He says :

"Researches on the effects of stress on the physical properties of matter have convinced me that the molecules, not only of glass, but of all solids which have been heated to a temperature at all near their melting-point, are, immediately after cooling, in a state of constraint, and that this state can be more or less abolished by repeatedly heating the solid to a temperature not exceeding a certain limit, and then allowing it to cool again (it is not only the heating but the cooling also that is efficacious). It appears that the shifting backward and forward of the molecules, produced by this treatment, enables them to settle more readily into positions in which the elasticity is greatest and the potential energy is least.

This "accommodation" of the molecules, as Professor G. Wiedemann and others have called it, is, as one might suppose, attended with alterations of the dimensions and other physical properties of solids, and is not confined to the release of molecular strain set up by thermal stress, but is extended to the strain set up by any stress whatever. As years roll on, the time of vibration of a metal pendulum gradually alters (and so, no doubt, do the lengths of our standard measures), the bulb of a thermometer diminishes in volume, a steel magnet parts with more or less of its magnetism, a coil of German-silver wire gains in electrical conductivity, etc. The changes in all these cases would probably be far less than they actually are if the temperature throughout the whole time could be maintained constant ; but this last is not the case—heating and cooling goes on more or less every day. We may assist the effect of time by artificially increasing the range of temperature, but it would appear that we must not exceed a certain limit of temperature, which limit depends partly upon the nature of the substance and partly upon the stresses that are acting upon it at the time. Thus, the internal friction of a torsionally oscillating iron wire which has been previously well annealed may be enormously diminished by repeatedly raising the temperature to 100° C., keeping it there for several hours, and then allowing it to fall again. The amount of diminution of internal friction depends upon the nature of the wire, and on the load which there is at the end of it (if the load exceeds a certain amount, the friction is increased instead of diminished). In attempting to "accommodate" the molecules in this manner the heating must, at any rate in some cases, be prolonged for several hours, and the substance should then be allowed to remain cold for a still longer period.

These principles appear to have a practical and an *important* application in mechanical engineering, where permanence or great precision is required in machinery. Thus, complaint is constantly made by the manufacturers of chilled cast-iron wheels, that it is impossible to keep the chill-molds true and round. These molds are frequently exposed to the temperature of molten iron and then cooled, and, consequently, in workshop phraseology they "get out of true." If the principle laid down by Mr. Tomlinson, that the constraint of such a solid "can be more or less abolished by repeatedly heating it to a temperature not exceeding a certain limit, and then allowing it to cool again," is correct, the obvious thing to do would be to anneal all chill-molds for car-wheels and other castings repeatedly before they are turned. If the theory above set forth is sound, chill-molds would remain true a much longer time if thus treated before turning than they will without being annealed. At present the practice is to turn them first and *then* change their shape. The suggestion is that their shape should be changed and made permanent *first* and they should then be turned. It is to be hoped that some wheel-maker will make a test of this suggestion and report the results.

The principle has, however, a much more extended application. It seems probable that if locomotive throttle-valves and the upper portion of the steam-pipe which forms the valve-seats were annealed *before* being finished, they would give much less trouble than they now do from leaking. In fact, it would seem to be a good plan to anneal all cast-iron steam-pipes before putting them into locomotives. Those in the smoke-box, especially, are exposed to high temperature, and are of such a form as to be very liable to change their shape by alternate heating and cooling.

It is also probable that a much higher degree of precision could be attained and *maintained* in machinery, such as lathes, planers, drills, and other machine tools, if their frames, beds, etc., were made permanent in form by annealing them before being finished.

AN ITALIAN LOCOMOTIVE.

THE *Railway Engineer* (London) for April contains engravings and a description of a locomotive which was built for the Southern Railroads of Italy, and was exhibited at the Paris Exhibition. It is referred to on account of its close resemblance to the common type of American passenger locomotives. It has four coupled drivers and a four-wheeled truck. The main driving axle is in front of the fire-box, and the trailing axle is at the back end below the fire-box. The cylinders are outside with the steam-chest on top. The valve-gear is of the ordinary shifting-link type connected to a rocker-shaft in the usual manner. The truck is suspended on swing-links and has long equalizing levers and a single spring between the axles. The cylinders are bolted to a heavy bed-casting. Even the cab is of the American style. Both the truck and the engine frames are made of plates which enables the fire-box to be several inches wider than is possible with American frames if it is placed between them. Evidently Signor Cavaliere E. Riva, the Locomotive and Carriage Engineer who designed the engine, recognizes good things when he sees them.

NEW PUBLICATIONS.

ELEMENTARY MANUAL ON STEAM AND THE STEAM-ENGINE, and A TEXT-BOOK ON STEAM AND STEAM-ENGINES: BY PROFESSOR ANDREW JAMIESON. London, England; Charles Griffin & Company.

The first of these books, the author says in his preface, was written expressly for apprentice engineers and elementary or first-year students studying Steam and the Steam-Engine. The second, which is a new edition of a work published some years ago, is the result of gradually improved lectures delivered on these subjects to the students of the Glasgow College of Science and Arts. Extensive and important additions, both to the text and the illustrations, the Author says, have been made in this new edition.

The three introductory lectures, of the first of these books, is on Elementary Mensuration; the seven which follow are on Heat, which are succeeded by three relating to the Temperature and Pressure of Steam. It is only when we reach the XIV lecture that the Steam-Engine itself is discussed. This lecture gives a general idea of the relative positions and motions of the chief parts of a steam-engine, and is succeeded by lectures on the Slide-Valve; the Indicator; Condensing and Non-Condensing Engines; Simple and Compound Engines; General Description of a Marine Engine; Details of Engines; Various Kinds of Valves; Condensers; Crank-Shafts; Boilers, and Boiler Mountings.

To each lecture is appended a series of questions on the subjects discussed.

The descriptions are written in a clear and simple style so that they can be readily understood, but some of the mathematical parts will probably appear rather formidable to an "apprentice engineer" whose education has not advanced farther than reading, writing, and ciphering, and who is shaky in square roots, mystified by Greek notation, and reduced to despair by algebraic formulæ.

The portion of the book relating to thermodynamics is written very clearly, and probably it would be difficult for a student to find a book from which he can get a good idea of the subjects explained so easily as he can from this Elementary Manual. The explanation of the differences between simple, compound, triple, and quadruple-expansion engines is also very clear. The description of a modern marine engine cannot be commended so highly. The engravings do not show the construction of the engine as distinctly as they might. In writing an elementary technical book of this kind skill in mechanical drawing, as Nasmyth said, "is one of the highest gifts in conveying clear and correct ideas, as to the forms of objects, whether they be those of a simple and familiar kind or of some mechanical construction." An author of a book of this kind needs this gift quite as much as he needs the ability to write clearly; and the lucidity of his explanations will depend very largely on the skill and ingenuity with which his drawings and illustrations are adapted to represent the subjects and objects to be explained.

The descriptions of the mechanical construction of the different parts of engines and boilers are all written very plainly, but they are confined, almost entirely, to one class, and in fact, to a single example of a class of engines.

The Text-Book, whose title is given above, contains most of the matter in the "Manual," the first three chapters on Mensuration in the latter book being omitted in the "Text-Book," two chapters on the early history of steam-engines being substituted instead of the Mensuration. Any one who has had occasion to look over many books on the Steam-Engine must have been impressed with the great waste of printers' ink, paper, and money, which has been entailed by the mistaken sense of duty, which nearly all authors of books of that kind seem to feel, and which leads each of them to repeat in each book which appears what has been written and printed again and again in earlier publications. If such a history was essential in understanding the modern steam-engine, it would be some reason for republishing it, but it does not do even that, but rather has the reverse effect by first filling the student's mind with a number of ideas of which he must then divest himself—if he can—as soon as he understands them. If an author of such a history would make some original researches, there might be some excuse for publishing it—at the end of a treatise. But they never seem to spend any time or effort in this direction, and they always begin their books with the history. A boy learns about a locomotive by seeing modern engines on railroads. When his curiosity is excited he begins to inquire what it is "that makes it 'go.'" Then he finds out how the steam gets in and out of the cylinders, and how the pistons turn the wheels, and so on, step by step, until he gets a tolerably complete understanding of the construction and operation of the machine which he sees at work every day. It would be difficult to induce such a boy to read up the history of the locomotive, but he will devour with avidity all the information within his reach which will tell him how a locomotive is started and stopped, and why one of them will pull more or run faster than another.

To begin an elementary treatise with a history is turning the natural order of education upside down. If the one which has been the object of the preceding criticism was relegated to an appendix or omitted altogether, it would improve the book materially.

In the "Text-Book" the lecture on The Distribution of Steam is supplemented with a description of Zeuner's diagram of valve-motion. That on the Indicator has a description added of the method adopted to combine the diagrams of the high and low-pressure cylinders of multiple-expansion engines. Different forms of brakes are also illustrated and described in a succeeding lecture. A lecture on the action of the crank and one on stationary engines follows. These are succeeded by another history of marine engines, descriptive of the various types which have been used. Different kinds of compound engines are also described. In the part relating to boilers a variety of

types are illustrated and the details of construction explained. The last Lecture is on locomotives—with a history—and a folded plate and description of a modern locomotive by Messrs. Dubs & Company.

In these days of multiplicity of books, it may well be questioned whether an author is justified in making a new book by merely amplifying an old one. Economy of human mental effort must certainly be studied more in the future than it has been in the past, and a useless multiplication of books or unnecessary increase in their size is, from a critic's point of view, inexcusable.

Professor Jamieson's two books are excellent elementary treatises on the marine engine, but they should be boiled down to one. He writes with great clearness, and a student cannot find anywhere better explanations of portions of the theory or descriptions of the construction of some of the parts of marine steam-engines than he will find in these two little treatises, which are recommended to students and mechanics generally who want information with reference to the important and interesting subject of which they treat.

Slide-Valve Gears; An Explanation of the Action and Construction of Plain and Cut-off Slide-Valves: by Frederick A. Halsey. New York; the D. Van Nostrand Company.

This little book is a treatise on Slide-Valve Gears, used on stationary engines, especially on the high-speed engines which are now so generally used. It discusses first the action of an ordinary slide-valve with a fixed eccentric, and then describes the method of analyzing it by means of the Bilgram diagram, which the Author prefers to that of Professor Zeuner. In the preliminary description the influence of the connecting-rod is ignored, but after the application of the diagram is explained, the methods of correcting the effect of the connecting-rod are elucidated.

The various kinds of slide-valves in use on modern high-speed engines, such as the Straight Line Valve, the Woodbury, Armstrong, Rice, Armington & Sims, Ide, and the Giddings valves, are illustrated by engravings, and their operation is explained. The application of shifting and swinging eccentrics to these valves, and the methods of equalizing the lead, points of cut-off, and exhaust are fully described.

Part III is devoted to the slide-valve with independent cut-off, and the method of analyzing it with the Bilgram diagram.

The Author says that the book "has been written with the aim of making it intelligible to any one who might be willing to make a serious effort to understand it. High authority exists for a mathematical treatment of the subject, but with this the Author has no sympathy. Designing a valve-gear is essentially a drawing-board process, and a mathematical treatment of it is simply an uncalled-for use of heavy artillery. The graphical treatment is therefore adopted throughout."

The development of high-speed engines has been attended with the introduction of many refinements in the design and construction of valve-gear. Descriptions of these—when they have been described—are scattered through trade catalogues and technical papers, and are consequently not easily reached by students or others who want information concerning this subject. The little book of Mr. Halsey is therefore a timely one. Generally it is written in a very clear style. The explanation of the Bilgram diagram is, however, not as plain as it might be, and it will puzzle many readers to get from it a complete idea of the methods of its application. The engravings—mostly diagrams—are made by the "wax process," and are excellent. It is a pleasure nowadays to get a technical book to review which is not loaded down with sloppy "process" cuts of all degrees of badness, which are often execrable copies of illustrations which have long since attained their majority.

Noiseless Motors and Steam Street Cars for City and Suburban Railroads. Philadelphia; issued by the Baldwin Locomotive Works; Burnham, Parry, Williams & Company.

This is an illustrated catalogue of the small locomotives and steam cars made by the Baldwin Locomotive Works for street and local railroads. The catalogue is preceded by an interesting chapter or paper summing up the advantages of such motors and the reasons in favor of their use, as compared with cable systems, electric cars, etc.

It is, perhaps, hardly necessary at this day to argue on the superiority of mechanical traction over horse-power for street railroads. The cable, the electric motor, and the steam car have each their advantages, and there is a wide field open for each in this country. While they are rivals to a certain extent, there is no doubt that all three can find a place.

The catalogue concludes with a list of some 70 roads on which these steam motors are in use, and a table giving results of operations on a number of lines.

The Traffic Capacity of the New York & Brooklyn Bridge Railroad: by G. Leverich, C.E. Brooklyn, N. Y.; published for the Author.

This is a very interesting study of the Brooklyn Bridge Railroad, which is one of the greatest passenger carriers in the world, and is written by an engineer who has had exceptional opportunities of studying the subject from his long professional connection with the Bridge. The regular average number of passengers is now over 100,000 per day, and as many as 159,259 have been carried in a single day, while the traffic is steadily increasing. At present it is obstructed and at certain hours of the day passengers are much inconvenienced by insufficient terminal facilities. Mr. Leverich seeks to show in his pamphlet what is the full capacity of the road and how it may best be utilized; and he presents carefully studied plans for new terminal stations. The question is a pressing one, and an attempt to improve the present condition of affairs deserves careful attention, especially when it is so well presented as in the present case.

Twenty-first Annual Report of the Board of Railroad Commissioners of Massachusetts, for the Year 1888–89: George G. Crocker, Edward W. Kinsley, Everett A. Stevens, Commissioners. Boston; State Printers.

This report usually receives much attention and contains valuable suggestions in relation to railroad management. It is hardly as long as usual this year, but has nevertheless much that is suggestive. The principal subjects to which reference is made this year are Grade Crossings, Stations, Boston Terminal Stations, and Electric Street Railroads. The first named question receives particular attention on account of the number of accidents to persons resulting from the crossing of highways by railroads at grade; but very little progress has so far been made toward separating them, even in Massachusetts.

The Coal Trade, 1890: by Frederick E. Saward. New York; published by the Author.

This is the seventeenth yearly number of this standard work, and there is, perhaps, very little more to be said of it than that it is as full of information, as carefully prepared, and as indispensable to all interested in the trade as its predecessors. As Editor of the *Coal Trade Journal* Mr. Saward has shown a thorough understanding of the subject, and a knowledge of the re-

quirements of the trade, which are equally apparent in his yearly manual. The tables given are as complete as they can be made with our present methods of gathering statistics, and they are presented in a clear and excellent way.

TRAITE GENERAL DES TARIFS DE CHEMINS DE FER: PAR F. ULRICH, CONSEILLER INTIME AU MINISTERE DES TRAVAUX PUBLICS DE BERLIN. Paris, France; Baudry & Compagnie.

This is the French edition of a very elaborate work on the tariffs and rates of the railroads in the different countries in Europe, written by Herr Ulrich, whose position in the Ministry of Public Works at Berlin has given him full opportunities of studying the subject, of which he has availed himself with German thoroughness.

The book is divided into two parts, the first being a general treatise on railroad rates and the principles which should govern them; their relations to private business and to the public interest. The second treats of the development of the systems adopted in the various European countries; of the methods upon which tariffs are made and changed, and of the laws and governmental regulations in relation to them.

The book does not deal with rates in this country, but to those who study the subject it will be a matter of much interest to compare European methods with our own, and especially to note where they have differed from ours and where they have approached them. Some reasons, both for the resemblance and the divergence can be found in Herr Ulrich's book.

It would be a difficult matter to write a similar one on American rates, but if some one who was qualified for the task would undertake it, such a book would be of value and might perhaps lead to the adoption of better systems than we have yet had.

BOOKS RECEIVED.

SPON'S TABLES AND MEMORANDA FOR ENGINEERS: BY J. T. HURST, C.E. TENTH EDITION. New York; E. & F. N. Spon. This little book contains a number of convenient reference tables, such as an engineer is most likely to need in a hurry, and is of a size ($1\frac{3}{4} \times 2\frac{5}{8}$ in.) convenient to carry in the vest pocket.

AIR BRAKE PRACTICE: BY J. E. PHELAN. New York; published by the *Locomotive Engineer*. This book is received too late for proper review and comment, which will be given hereafter.

THE SOUTH'S REDEMPTION FROM POVERTY TO PROSPERITY: BY RICHARD H. EDMONDS. Baltimore; published by the *Manufacturers' Record* Company (price, 25 cents). This pamphlet is a republication of a special edition of the *Manufacturers' Record* issued in December of last year, with additional statistics, bringing the reports down to the close of the year. It has been thought that the matter in this shape would be more convenient for use and for subsequent reference. It presents an account of the recent progress of the South in manufacturing and industrial enterprises, showing a very remarkable record.

PROVIDENCE TERMINAL FACILITIES: THE ACCEPTED PLAN FOR THEIR IMPROVEMENT. Providence, R. I.; reprinted from the Providence *Journal*.

OCCASIONAL PAPERS OF THE INSTITUTION OF CIVIL ENGINEERS. London, England; published by the Institution. The present issue includes papers on Triple-Expansion Engines and Engine Trials, by Professor Osborne Reynolds; Water-Tube Steam Boilers for Marine Engines, by John I. Thornycroft, with abstracts of the discussions on both papers.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS; REVIEW OF THE MODERN THEORIES OF ELECTRICITY: BY PROFESSOR W. A. ANTHONY. New York; published by the Institute, R. W. Pope, Secretary.

REPORTS FROM THE CONSULS OF THE UNITED STATES, ISSUED FROM THE BUREAU OF STATISTICS, DEPARTMENT OF STATE: NO. 113. FEBRUARY, 1890. Washington; Government Printing Office.

FOURTH REPORT OF THE ASSOCIATION OF AMERICAN RAILWAY ACCOUNTING OFFICERS: NEW ORLEANS MEETING, JANUARY 22 AND 23, 1890. Chicago; published by the Association, C. G. Phillips, Secretary.

PROCEEDINGS OF THE SECOND ANNUAL CONVENTION OF THE IOWA SOCIETY OF CIVIL ENGINEERS AND SURVEYORS HELD AT DES MOINES, IOWA, DECEMBER 27 AND 28, 1889: SETH DEAN, SECRETARY. Glenwood, Iowa; published for the Society.

THE SEWER GAS QUESTION: BY E. S. MCCLELLAN, M.D. New York; issued by the Du Bois Manufacturing Company.

COMPARATIVE VALUE OF HEART AND SAP PINE: BY RICHARD LAMB, C.E. RELATIVE STRENGTH OF HEART AND SAP PINE: BY W. L. BROWN. Wilmington, N. C.; issued by the Authors.

1. ELECTRIC TRANSMISSION OF POWER; MILL WORK. 2. FACTS ABOUT THE SPRAGUE ELECTRIC STATIONARY MOTORS. 3. THE SPRAGUE ELECTRIC RAILROAD SYSTEM. New York; issued by the Sprague Electric Railway & Motor Company. These three pamphlets contain illustrated descriptions of a number of applications of the electric motor.

THE VENTILATION OF BUILDINGS: BY ALFRED R. WOLFF, M.E., CONSULTING ENGINEER. New York; published for the Author.

SPRAGUE ELECTRIC EQUIPMENT COMPANY: CATALOGUE OF ELECTRIC RAILROAD APPARATUS AND SUPPLIES. Chicago; issued by the Company.

CATALOGUE AND PRICE LISTS OF THE BROWN & SHARPE MANUFACTURING COMPANY: MACHINERY, GAUGES AND TOOLS FOR ACCURATE MEASUREMENT. NEW EDITION, 1890. Providence, R. I.; issued by the Company.

KALAMAZOO RAILROAD VELOCIPEDE CAR COMPANY: ILLUSTRATED CATALOGUE. Kalamazoo, Mich.; issued by the Company.

RICHARDS' PATENT OPEN-SIDE PLANING AND SHAPING MACHINE: ILLUSTRATED CATALOGUE AND DESCRIPTION. Philadelphia; published by Pedrick & Ayer, Manufacturers.

ABOUT BOOKS AND PERIODICALS.

THE TECHNOLOGY QUARTERLY for February has an interesting article on the Study of Statistics in Colleges and Technical Schools, by Francis A. Walker, and several other papers of much technical value.

In the CENTURY for April Major J. W. Powell continues his series by an article on the Non-Irrigable Lands of the Arid Region. A paper of much interest just now is Suggestions for the Next World's Fair, by M. Georges Berger, who was Director of the last Paris Exposition and so speaks with authority.

The POPULAR SCIENCE MONTHLY for April has two articles which will be read with interest—On the Natural Inequality of Man, by Professor Huxley, and on a Lesson in Co-operation, by C. N. Ousley. The article on Science in the High School, by Professor Jordan, deserves a careful reading.

The Electric Railway of To-day, by Joseph Wetzler, in SCRIBNER'S MAGAZINE for April, is a very interesting account of what has actually been done in the application of the electric motor to street cars. It describes the various systems in use clearly and without any undue bias toward any one system and explains the main principles upon which all are based.

In the JOURNAL of the Military Service Institution for March there is the first part of an exhaustive article on the Develop-

ment of Submarine Mines and Torpedoes, by Lieutenant James C. Bush; articles on the Instruction of Non-commissioned Officers, by Lieutenant H. C. Carbaugh; Military Instruction of Our Youth, by Lieutenant Frank Eastman; India, China and Japan, by Captain S. M. Mills; Mackenzie's Last Fight, by Captain John G. Bourke. The number also contains some interesting translations and reprints from foreign journals.

In the March number of the JOURNAL of the New England Water-Works Association there is published a long and exhaustive paper on Fire Streams, by John R. Freeman, giving an account of a number of experiments made, with practical tables based on the results obtained. To those concerned it is a very interesting and valuable article.

In the March number of HARPER'S MAGAZINE General Wesley Merritt described the Army of the United States, and in the April number he gives some idea of the work it has to do in a graphic and interesting account of Three Indian Campaigns.

The WESTERN ENGINEER for March, published by the Pond Engineering Company, has two valuable papers, one on the Steam-Engine, by F. E. Sickles, the other Boiler Feed Pumps, by Frank H. Pond.

In OUTING for April the military articles are continued by one on the Alabama State Troops. There are a number of others of interest to all who enjoy out-door sports.

The April ARENA has several controversial articles which can hardly fail to call out sharp replies. Discussion is the basis of the new magazine, however, and the free statement of views will be welcomed.

A CAUSE OF BOILER EXPLOSIONS.

(Abstract of paper read before the Scientific Society of Bridgeport, Conn., by Mr. Frank G. Fowler.)

THE frequent occurrence of boiler explosions under circumstances which make any explanation of the causes difficult or apparently impossible, has led to the putting forward of many theories, most of which are based entirely upon assumptions or hypotheses, and not on actual facts or experiments. In this paper there is presented a theory founded on some experiments of a very remarkable character, the results of which seem to contradict all our accepted ideas.

Briefly stated, the experiment—which has been repeated many times, under circumstances which seem to preclude all possibilities of mistake—is this. A small closed boiler, partially filled with water, in about the same proportions as ordinarily used in service, is heated by a flame until the pressure rises, say, to 40 lbs. Now this boiler being suddenly disturbed or reversed in position, without any additional heat being applied, the pressure is at once more than doubled—in the case actually described rising to 82 lbs. This rise in pressure, although taking place suddenly, is not momentary only, but the gauge continues to show the higher pressure for some time, falling gradually, but slowly.

Now further, this sudden change in pressure occurs when the boiler has been filled with water from any ordinary source—as hydrant, spring, rain or river water—and no steam has been allowed to escape. But if the water has been "de-aerated"—that is, if steam is allowed to escape, forcing out and carrying with it what air may have been enclosed in the boiler, and the agitation or reversal of the boiler is then repeated, the rise in pressure will be very small; in the case actually noted and described, the change was only from 40 to 42 lbs.

It may be noted that this experiment may be very easily and simply made by using a piece of iron pipe with a cap screwed on each end and provided with a steam gauge. It has been made in this way a number of times, and if strong pipe is used very high pressures may be safely applied. In one case on record the pressure rose, on reversing the tube or boiler, from 85 lbs. to 172 lbs., recorded by a reliable gauge.

Now it may be safely said that a boiler fails or explodes because the pressure within it is greater than its strength will bear. Where it fails from any local defect, such as a corroded plate, bad workmanship, lack of proper bracing or the like, there are generally premonitory warnings, and the failure, moreover, is usually only partial and leaves traces by which the cause can be detected. But where a boiler gives way at once, and there is no sign of any defect, it may be assumed without much doubt that there has been excessively high pressure.

The experiments under consideration seem to show that this excessive pressure may be suddenly developed in a way not clearly understood. By the accepted laws the pressure of steam cannot be increased without an addition of heat, and the pressure in a boiler could not rise from 40 to 82 lbs., as stated above, without an increase in temperature, which has certainly not been apparent in the experiments made.

To account for the results, therefore, the Author believes that the increase in pressure noted is due to the air and other gases conveyed into the boiler with the water, and that when these gases are suddenly commingled with the water by any disturbance of the boiler, it is their expansion which raises the pressure and produces destructive results. In other words, the pressure in a boiler may be raised far beyond the limit of safety without warning, without the application of additional heat and in a way which will leave no trace of its cause.

To corroborate this theory, the following points may be noted:

1. Many explosions take place at the moment when an engine is started—that is, when the throttle valve is opened and steam is drawn rapidly from a boiler which had been up to that time entirely closed. Here the conditions approach those of the experiments—that is, the boiler still contains the air and other gases which it held when the fire was started, while the opening of the throttle produces a disturbance which, while less violent than a reversal of the boiler would be, is sufficient to commingle the gases as above stated.

2. The class of boilers in which explosions occur more frequently than in any other is the "rotary digester" used in many mills. In these boilers there can be no suspicion of overheated crown-sheets, low water or similar causes, as they are heated by steam and not by the direct application of fire. There is a continued introduction of water containing air and gases, and the boiler itself is in constant rotation, so that those gases are thrown out and liberated from the water.

3. The fact that boilers seldom explode from "unexplained" or "mysterious" causes when the engine which they supply is working steadily. Under these conditions the water in them is at least partially de-aerated by the drawing out of the steam; for while some air and other gases are introduced with the feed-water, the quantity in the boiler is very much less than when steam is first raised by starting a fire under a boiler which is partly filled with air. Moreover, explosions in marine boilers, which are fed with water from the condenser, or distilled water, are almost unknown.

4. Experiments made by heating closed boilers until they exploded showed that the destructive effects of the explosion are considerably greater where the boiler is filled, say two-thirds, with ordinary hydrant water and the rest with air, than where the water has been de-aerated by allowing steam to escape, carrying with it the confined air and gases, before the boiler was closed and heated to the exploding point.

It may be stated that the Author has not based his theory upon a single experiment, but upon a series of experiments repeated many times under conditions varying as much as possible, and continued so long as to prevent any possibility of mistake; and upon these experiments he bases his explanation of those explosions which are called "mysterious." That the results of the experiments are of a very remarkable character cannot be denied.

A COMPOUND PASSENGER LOCOMOTIVE.

THE accompanying illustration, from the London *Engineer*, is a general view of one of five compound locomotives on the Worsdell & Von Borries system, recently built for the Northeastern Railway of England, and now in use on the express passenger trains of that line. Fig. 2 is a front view of the engine, showing the arrangement of the cylinders. The engine, as will be seen, is inside connected, and has a single pair of drivers.

The boiler is of steel, the barrel being 51 in. in diameter and 10 ft. 7 in. long. The fire-box is of copper, and is 6 ft. 3½ in. long, 3 ft. 2¾ in. wide, 6 ft. 3½ in. deep at the front end and 5 ft. 3½ in. at the rear end. There are 203 tubes, of brass, 1¾ in. diameter and 10 ft. 11 in. long. The fire-box heating surface is 123 sq. ft. and that of the tubes 1,016 sq. ft., making a total of 1,139 sq. ft. The boiler is built to carry 200 lbs. pressure, but 175 lbs. is the working pressure generally used.

The driving wheels are 7 ft. 7¼ in. in diameter, and the trailing wheels 4 ft. 7¼ in.; the truck wheels are 3 ft. 7¼ in. All the wheels are of cast steel, with steel tires. The truck axles have journals 6 × 9 in., and the trailing axles 7 × 11 in. The crank axle is of steel, with journals 8 × 9 in., and the crank bearings are 8¼ in. in diameter and 5 in. long.

The high-pressure cylinder is 20 in. in diameter and the low-pressure cylinder 28 in., both being 24-in. stroke. The small cylinder has steam-ports 1¾ × 17 in. and exhaust-ports 3½ × 17 in.; for the large cylinder the steam-ports are 2 × 20 in. and the exhaust-ports 3½ × 20 in. Joy's valve gear is used, the valve for the high-pressure cylinder having 1⅛ in. lap, 0½ in. inside clearance, 0$\frac{3}{16}$ in. lead and 4⅝ in. maximum travel; the low-pressure valve has the same lap, inside clearance and lead, and 5¾ in. maximum travel. The piston-rods are 3½ in. in diameter, and the connecting-rods 6 ft. 1 in. between centers.

The peculiar arrangement of the cylinders is made necessary by the great size of the low-pressure cylinder and the narrow space between the frames. The steam-chests are placed outside, as shown in fig. 2.

The total weight of the engine in working order is 104,550 lbs., of which 35,670 lbs. are carried on the truck, 39,760 lbs. on the driving-wheels and 29,120 lbs. on the trailing wheels.

The frames are of the plate type, and are of steel 1 in. thick; they are 4 ft. apart. The truck wheels are 6 ft. 6 in. between centers. The distance from the center of the truck to center of driving wheel is 10 ft.; center of driving to center of trailing wheel, 8 ft. 8 in. The total length of the engine is 28 ft. 8 in.

The tender, which is carried on three pairs of 45-in. wheels, has a total weight, loaded, of 89,700 lbs.; it can carry 3,940 galls. of water and 4 tons of coal. The great tank capacity is necessary, as these engines have to make the run from Newcastle to Edinburgh, 125 miles, without stopping.

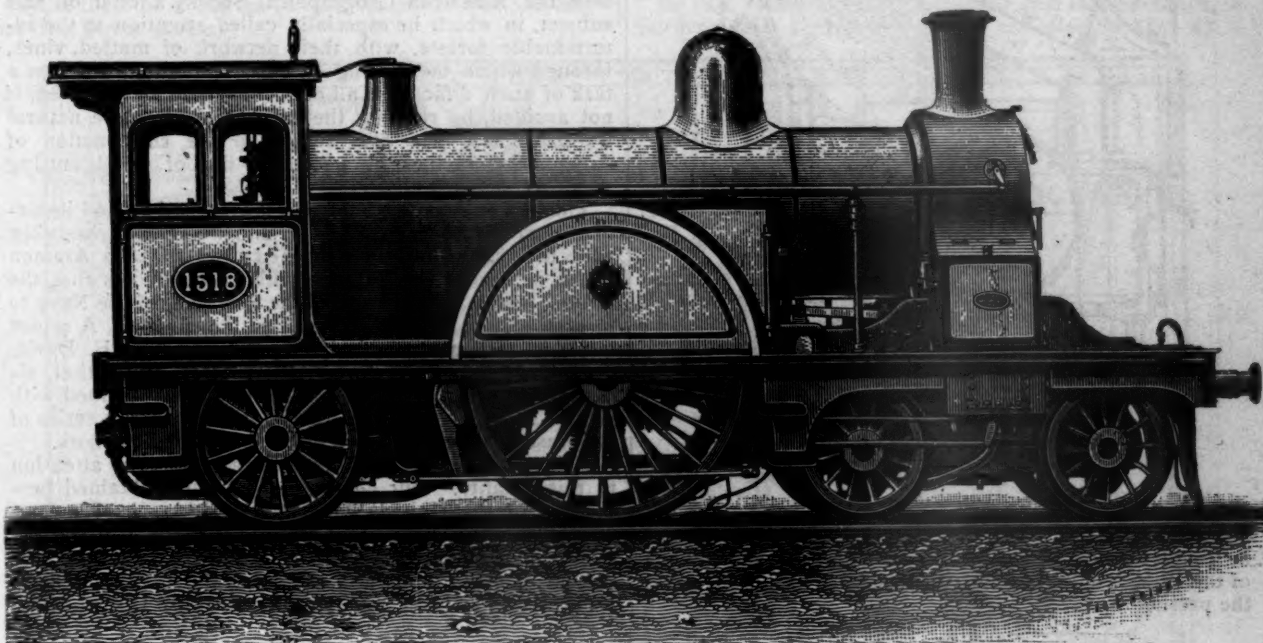
As to their performance in service, it is stated that with these engines the saving in water as well as in fuel is from 18 to 20 per cent. as compared with the non-compound engines on the same service. As a matter of fact, the consumption of all the compound passenger engines working the same relative trains with the non-compound engines averaged, during 12 months, a net saving of 22 per cent. in coal.

In designing these engines the greatest consideration has been given to all the working details, so that the long distance can be run at the high speeds required with as little extra need for attention on the part of the men in charge as possible, and every facility has been provided for their ready control. The personal comfort of the enginemen has also been attended to, so that they can perform the duties that devolve upon them under the most favorable circumstances. The first of these engines, No. 1,517, was put to work in October last, and this, with the other three, has been working the fast passenger traffic between Newcastle and Edinburgh regularly, the number of vehicles varying from 10 to 22; in either case these engines have no difficulty in running within time.

On one occasion a trial was made between Newcastle and Berwick with a train of 32 empty carriages, the distance being 67 miles, and the total weight of train 270 tons; the time was 78 minutes, or three minutes less than that of the regular Scotch express, and with the heaviest loads it is quite unnecessary to provide an assisting engine.

The consumption of coal is, indeed, much lower than anticipated. At the end of October, No. 1,517 engine averaged 26.4 lbs. of coal per mile. These engines steam well and run exceedingly steady. With a special train of 18 six-wheeled carriages a speed of about 90 miles per hour—the highest on record by several miles—was obtained, and at that speed there was not the slightest inconvenience in moving about on the foot-plate or front end of the engine.

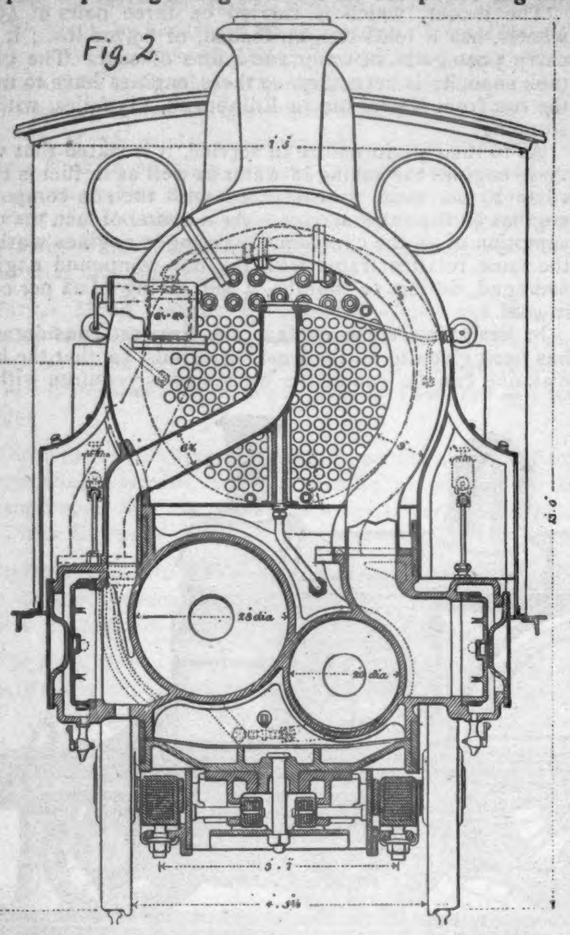
It may be stated that several more engines of the same



COMPOUND PASSENGER LOCOMOTIVE NORTHEASTERN RAILWAY, ENGLAND.

pattern are now under construction for the Northeastern Railway, and that there are now in use on that road 32 compound passenger engines and 162 compound engines

Fig. 2.



in freight service. In all about 600 compound locomotives of the Worsdell & Von Borries type have been built up to the present time.

INTEROCEANIC COMMUNICATION BY WAY OF THE AMERICAN ISTHMUS.

By Lieutenant Henry H. Barroll, U.S.N.

(*Continued from page* 173.)

VIII.—THE SYSTEMATIC SURVEYS BY THE UNITED STATES.

The continued prosperity of the West and the Northwest during the four years of Civil War caused the question of an Interoceanic Canal to be taken up with vigor after peace was restored.

Various "best routes" were claimed, generally by individuals who had obtained "concessions" from the Central American States.

England, France and the United States had each, during the first half of the nineteenth century, contributed to the work of exploration and extending geographical knowledge of the Isthmus; but to the latter nation rightly belongs the honor of having fully and clearly demonstrated, since the war, by hundreds of lines of survey, the best and most feasible lines of transit.

Humboldt had suggested that a party, fully equipped, be started along the backbone of each ridge, and thus, by deliberate surveys, prove where existed the lowest depressions; and then to devote attention only to these points. But the reverse of this was the plan which was finally adopted.

Lieutenant (now Rear-Admiral) Daniel Ammen, U.S.N., became attracted by a passage in the report of Lieutenant Strain with regard to that ill-fated expedition, which passage stated that he had heard, or thought he had heard, the sound of the evening gun aboard the *Cyane*, the vessel that he had four days previously left.

Acting then upon the supposition that the sound-wave would follow the line of least resistance, Ammen, in 1856, projected and presented to Mr. Toucey, then Secretary of the Navy, a systematic plan for a survey of the Isthmus of Darien, accompanied by a request that he be allowed the necessary means to prosecute the work.

Ammen based his system on the axiom that *the bed of a stream or river indicates the line of lowest levels in the whole basin drained by that stream;* and he was convinced that by following up the several streams he would thus find lines of lowest levels, and then, avoiding the higher divides, might confine the more minute explorations to the lower passes.

Lieutenant Ammen's request was not granted; and his sea duties calling him to the Pacific, he had no further chance to pursue the subject until 1860, when he read before the American Geographical Society a letter on this subject, in which he especially called attention to the interminable forests, with their network of matted vines, through which the cutting of a bare walking trail was a task of such difficulty; all of which could be lessened, if not avoided, by running the surveys along these natural water-courses. He also suggested the construction of dams across ravines, by which the line of canal cutting would be sensibly shortened.

This letter was read during the excited period immediately preceding the Civil War, and no action was taken upon the suggestions it contained; but in 1866 Ammen again presented the subject with such success that the United States Senate directed the Secretary of the Navy to furnish a list of all known data on the subject. A report made in response to this by Rear-Admiral C. H. Davis, Superintendent of the Naval Observatory, stated that, although scanty information had so far been obtained with regard to the Isthmus of Darien, yet of all the series of isthmuses, that of Darien possessed the finest harbors.

This great natural advantage attracted special attention to this locality. Our Government, having obtained permission of the United States of Colombia, in 1869 commenced a systematic survey first of the Isthmus of Darien, after the manner suggested by Ammen; and later this system of exploration was carried to the other isthmuses, all explorations being made by officers of the United States Navy.

In 1872 President Grant appointed a Commission, consisting of three persons—Commodore Daniel Ammen, U.S.N., General A. A. Humphreys, U. S. Corps of Engineers, and Mr. C. P. Patterson, then Superintendent of the Coast Survey—whose province it was to study the results furnished by the United States exploring expeditions; and after the appointment of this Commission, all work by the Naval parties was executed under its direction.

Thus systematized, the surveys continued without interruption for the next 10 years, save for the necessary avoidance of the unhealthy rainy seasons.

No less than 25 different routes have been proposed, and none of these abandoned until careful investigation had shown that either there was some more practicable route in that vicinity, or else that the expenses would have been too overwhelmingly great to have justified the construction of a canal.

The following list shows the principal routes that have been proposed as possible lines for a canal, all of which have been fully investigated; while hundreds of reconnoissances have exhibited the topography on each side of the proposed lines.

Isthmus of Tehuantepec.

From the Bay of Campeche, *via* Tarifa, to the Gulf of Tehuantepec.

Isthmus of Honduras.

From the Bay of Honduras to the Bay of Fonseca.

Isthmus of Nicaragua.

From Greytown, *via* Lakes Nicaragua and Managua, to the Bay of Fonseca;

From the same lakes to Port Realejo ;
From the same lakes to Rio Tamarinda ;
From Greytown, *via* Lake Nicaragua and Sapoa River, to the Bay of Salinas ;
From Greytown, *via* La Virgen Bay, to San Juan del Sur ;
From Greytown, *via* Rio Lajas, to Brito ;
From Greytown, *via* Rio Medio, to Brito ;
From Greytown, *via* Buena Vista Pass ;
From Greytown, *via* the Valley of the Gil Gonzales ;
From Greytown, *via* the Valley of the Ochomoga.

Isthmus of Costa Rica.

From Chiriqui Lagoon to the Gulf of Dulce.

Isthmus of Panama.

From Aspinwall to Panama ;
From San Blas Bay to the Bayamo River.

Isthmus of Darien.

From Caledonia Bay to the Gulf of San Miguel ;
From the Gulf of Darien (Uraba) to the Gulf of San Miguel (the Tuyra Route) ;
From the Gulf of Darien, *via* the Peranchita River, to the Gulf of San Miguel (the Tuyra-Peranchita Route) ;
From the Gulf of Darien, *via* the Atrato and Truando rivers, to the Pacific (the Truando Route) ;
From the Gulf of Darien, *via* the Atrato and Napipi rivers, to Cupica, or to Chiri Chiri Bay (the Atrato-Napipi Route) ;
From the Gulf of Darien, *via* the Atrato and Bojaya rivers, to the Pacific (the Bojaya Route) ;
From the Atrato River, at its headwaters, *via* the San Juan River, to the Pacific, near Buenaventura Bay.

The surveys may be said to have extended over the entire territory, since it became the province of the surveyors to explore all localities not already definitely known to be impracticable.

The data thus obtained demonstrated succinctly the advantages and disadvantages of each of the principal localities under investigation.

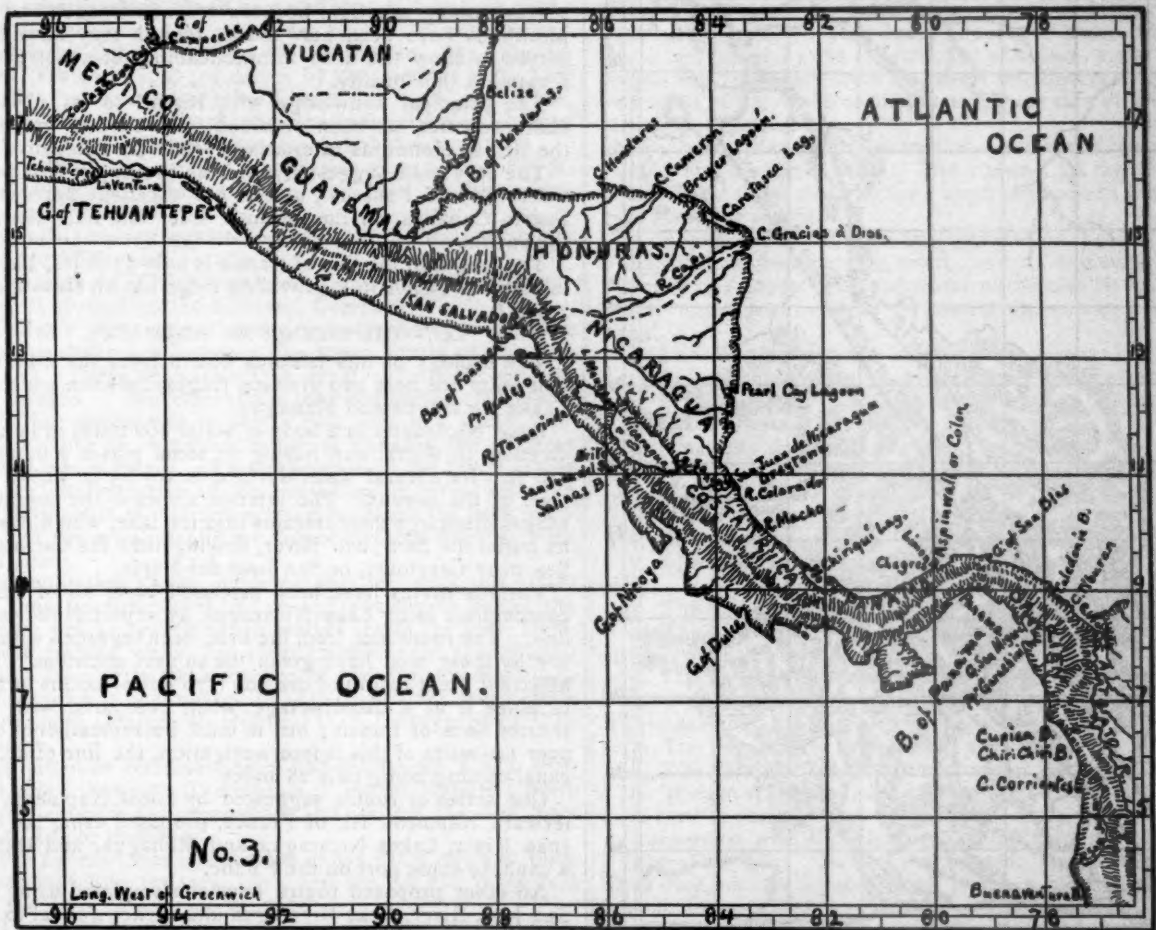
IX.—THE TEHUANTEPEC ROUTE.

There is but a single proposed canal route across this isthmus, extending from the Bay of Campeche, on the Atlantic side, and following the valley of the Coatzacoalcos River, crossing the divide at Tarifa Pass, and thence to the Bay of Salinas Cruz, in the Gulf of Tehuantepec.

During the time of Cortez—1520–34—this territory was explored with a view to interoceanic communication, and traffic was carried on between the two oceans by way of this mountain pass.

Tradition falsified its topography, and it became currently reported that the depression known as Tarifa Pass had an elevation of only a few feet above the level of the sea ; but in 1771 Spanish engineers made a survey between the Bay of Campeche and the Gulf of Tehuantepec, which showed the mountainous nature of the country traversed.

In 1836, Mexico having achieved her independence, a Governmental survey was made ; and also, in 1842–43, a survey by a Commission, under the direction of Don José Garay, who had received a concession from the Mexican Government to construct a canal.



This survey claimed an elevation of only 684 ft. at Tarifa Pass, and proposed a lock canal, to be supplied with water by a feeder canal from the two rivers, Chicapa and Ostuta. The length of the canal proper was to be 50 miles, and that of the feeder, 15 miles. The elevation to the summit was to be attained by 161 locks. The canal, as proposed, must have been of small dimensions, since its estimated cost was only $17,000,000.

The time allowed for the commencement of the work was twice extended, and finally, in 1849, the project became changed into a scheme for the construction of a freight and passenger railway over the same line.

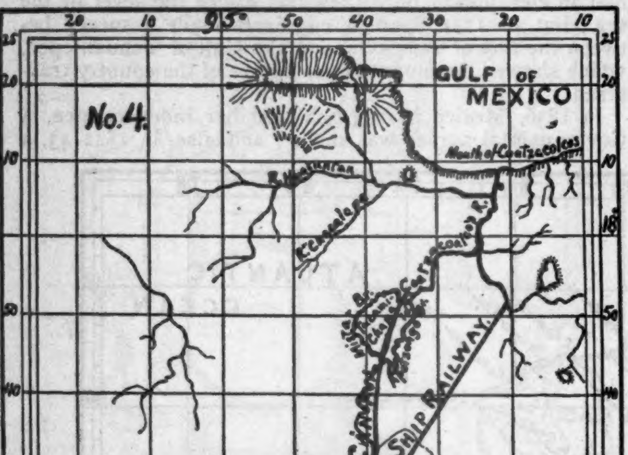
In 1870 Commander (now Rear-Admiral) Shufeldt,

U.S.N., was ordered to make surveys here to determine:

1. The advisability of improving the terminal harbor;
2. To examine the character of the soil and natural obstacles that lay along the proposed line of canal;
3. To find out if there existed in the above-mentioned rivers a sufficient supply of water for a lock canal.

Shufeldt's report showed that the joint delivery of the Ostuta and Chicapa rivers was not sufficient to feed a ship-canal; and, moreover, that it would be impossible to effect a junction between them, as the Ostuta lies 180 ft. below the summit.

He also found that the Coatzacoalcos and Blanco rivers would furnish, at the summit-level, water supply sufficient only for a canal of 22 ft. depth, 60 ft. width at bottom and



162 ft. width at the water surface. The total length of the canal would be 144 miles, crossing an elevation of 754 ft. (reduced by the 22 ft. of canal to 732 ft.) by a system of 140 locks.

To supply water at the summit-level a feeder canal would be necessary, which involved a dam across the headwaters of the Coatzacoalcos River 122 ft. long and 86 ft. high, and another dam across the Blanco River 16 ft. high and 140 ft. in length.

There was necessary, in addition, a feeder canal, 27 miles in length, involving 3 miles of heavy cutting, $3\frac{1}{2}$ miles of tunneling, and finally an aqueduct 1,200 ft. in length.

The Pacific terminus required for the formation of an anchorage the construction of a breakwater 2,000 ft. long; while, although on the Atlantic side there is good anchorage in the Coatzacoalcos River, yet the bar at the mouth of that river showed but 15 ft. in the channel, thus necessitating expensive dredging to form an entrance to the canal.

Shufeldt made no estimate of cost, merely submitting the facts that the surveying parties under his command had found to exist; yet, according to Lieutenant Sullivan's report (page 105), using the same scale of prices that were used in estimating the cost of the Nicaragua Canal, the engineer's estimate here would amount to $130,000,000.

The plan adopted by the Canal Commission appointed by President Grant was to use 100 per cent. instead of the 25 per cent. usually allowed by engineers to cover contingencies. This applied to the above estimates would make the cost amount to $260,000,000.

From the time of Shufeldt's surveys, the idea of cutting through the Isthmus of Tehuantepec has been abandoned, and in its place is now proposed transit across this isthmus by means of a ship railway.

X.—THE HONDURAS ROUTE.

This isthmus, coming next in geographical position, deserves passing mention, because reconnoissances and explorations have been here made, though they have only served to show the utter impracticability of constructing a canal in this locality.

The principal knowledge with regard to its physical characteristics has been obtained from surveys made by the British Honduras Interoceanic Railway Company.

The only route suggested was from the Bay of Honduras to the Bay of Fonseca; and it has excellent harbors in Puerto Caballos, on the Atlantic side, and La Union, on the Pacific.

The length of the line of transit is only 93 miles, but the lowest depression in the dividing ridge has an elevation of 2,956 ft.

XI.—THE ISTHMUS OF NICARAGUA.

The orology of this isthmus differs from the others in that there are here two dividing ridges, between which lie Lakes Nicaragua and Managua.

Lake Nicaragua is a body of water 100 miles in length, 50 miles in width, and having in some places a depth of 150 ft. Its natural water-surface is 107.63 ft. above the level of the oceans. The interior slopes of the mountain ranges discharge their streams into the lake, which has for its outlet the San Juan River, flowing into the Caribbean Sea near Greytown, or San Juan del Norte.

Various routes have been proposed here, all of which contemplate using Lake Nicaragua as a part of the canal line. The route has, from the first, been regarded with favor by those who have given the subject attention. The apparent great length of the line (170 miles) seems at first to place it at a disadvantage, when compared with the shorter lines of transit; but it must be remembered that over 140 miles of this is free navigation, the line of actual canal-cutting being only 28 miles.

One series of routes suggested by Louis Napoleon, afterward Napoleon III. of France, proposed using the San Juan River, Lakes Nicaragua and Managua, and thence a canal to some port on the Pacific.

All other proposed routes have contemplated using the San Juan River, Lake Nicaragua and thence a canal to the Pacific.

Examinations made by Civil Engineer A. G. Menocal, U.S.N., showed the impracticability of using Lake Managua; and surveys made by parties under Commander Lull, U.S.N., and Mr. Menocal, finally reduced the proposed routes to that from Greytown *via* the San Juan River, Lake Nicaragua and the Rio Lajas to Brito.

This route was presented for the consideration of the Paris International Canal Conference in 1879, with an estimated cost of about $65,000,000, but it failed then of acceptance. The route will be discussed at more length in connection with the Panama and Atrato-Napipi routes, these being considered the three most prominent proposed lines.

XII.—THE ISTHMUS OF COSTA RICA.

Three routes have been proposed across this State, as follows:

1. From the mouth of the Colorado River to the Gulf of Nicoya;

2. From the mouth of the Rio Macho to the Gulf of Nicoya;

3. The Chiriqui Route.

The latter is the only route deserving special mention. This extends from Chiriqui Lagoon, on the Atlantic side, to the Gulf of Dulce, both of which are fine harbors, while the line of transit is only 50 miles.

There is, unfortunately, an elevation of 1,600 ft. to be crossed, and this, within five miles of the Pacific Coast, while there is no adequate water-supply for lockage.

XIII.—THE ISTHMUS OF PANAMA.

There have been two routes proposed across this isthmus, as follows:

1. From Aspinwall to Panama;

2. From San Blas Bay to the Bayamo River.

1. The line *from Aspinwall to Panama* has been so thoroughly discussed that its plan and profile are familiar to all interested in the subject.

The isthmus has received numerous instrumental surveys, among which are to be noted that of Lloyd in 1828; that of Garella in 1844; a survey by J. C. Trautwine and another by Colonel George W. Hughes in 1849; one by G. M. Totten in 1857; a survey by Commander E. P. Lull in 1875; also a survey by Lieutenant L. N.-B. Wyse, French Navy, in 1877–78, and finally the detailed surveys made by the De Lesseps Panama Canal Company.

Lloyd's survey crossed a greatest elevation of 633 ft. He demonstrated that the mean tide-level of the oceans was nearly the same.

Garella's survey was made under the authority of Louis Philippe of France.

The surveys of Trautwine and Totten were made in the interest of the Panama Railroad Company.

Totten's observations showed conclusively that there was no difference between the mean levels of the two oceans. There is, however, a great difference between the ranges of the tide at the terminal ports. At Aspinwall the highest tide is only 1.6 ft. above a mean low-water plane of reference, while at Panama the greatest rise of tide is 21.3 ft. This difference in the range is due to the configuration of the coast-line on either side, the outlying chain of Antilles serving to break the tidal influence at Aspinwall, while the Bay of Panama offers no such obstacle.

Investigation shows, however, that although the Atlantic may be sometimes above and sometimes below the Pacific, yet at mid-tide their waters are at the same level.

One feature which has greatly assisted the examination of this locality is the existence of the Panama Railroad. This road was commenced in 1850, the survey being made by Colonel George W. Hughes, U. S. Topographical Engineers.

A previous reconnoissance had discovered a gap with not more than 300 ft. elevation; Colonel Hughes's party found a still lower depression, and located the line from Navy Bay to Panama.

The railroad was constructed in five years, the first blow being struck in January, 1850, and the last rail being laid on the night of January 28, 1855.

The road is, in length, 47 miles, 3,020 ft., and surmounts an elevation of 263 ft. above mean tide of the Atlantic by a cut of 24 ft., the summit ridge being 287 ft. above this plane of reference. Of the entire distance, 23⅝ miles are level and 28⅝ miles are straight. There are some very abrupt curves, and the maximum grade is 60 ft. to the mile.

Since the completion of this railroad attention has been called to this portion of Central America as the most convenient point at which to connect the oceans.

XIV.—COMMANDER LULL'S SURVEY.

In 1875 Commander E. P. Lull, U.S.N., by direction of the United States Canal Commissioners, made a close instrumental survey in the vicinity of the Panama Railroad, with a view to the construction of a lock-canal, it being deemed impracticable, from the knowledge of this isthmus, to construct a tide-level canal.

The estimated cost of a lock-canal, as computed from the data furnished by this survey, was $94,511,360. Its dimensions were as follows: Length from sea to sea, 41.7 miles; width at surface, 150 to 160 ft.; width at bottom, 60 to 70 ft.; depth, 26 ft.

The summit-level was placed at 123¾ ft., and was to be overcome by the use of 24 locks—12 each side—each with a lift of 10.3 ft.; and in addition a tidal lock at the Pacific terminus was necessary.

The Chagres River, near its junction with the Obispo, changes course abruptly to the northward, which involved the necessity of carrying the canal over this river by a viaduct sufficiently elevated to allow the flood of waters to pass underneath it. This viaduct would be 1,900 ft. long, and elevated 44 ft. above the bed of the Chagres. (*Lieutenant Sullivan's report, page* 118.)

The surface of the water in this viaduct would be the summit-level of the canal. To supply the summit with water, it was proposed to dam the Chagres at a point about 12 miles above the viaduct, raising the waters 36 ft. above the ordinary level; thence the water would be conducted by a feeder canal 10.2 miles long, and passing through seven tunnels aggregrating 13,700 ft. in length, and over two aqueducts into a receiving basin 22 acres in area—this basin to be formed by the construction of a dam, 1,760 ft. in length and 74 ft. high from its lowest foundation, between two spurs of the range of hills forming one side of the valley of the Chagres.

The basin was to be located about 1,000 ft. from the Pacific end of the viaduct. The channel of the Obispo would have to be changed for a short distance in order to give room for the dam.

A channel would have to be excavated in the harbor of Panama for a distance of 9,200 ft., and at Aspinwall for a distance of 1,800 ft. A breakwater would also be required at the latter port in order to protect the entrance to the canal.

The advantages claimed for this route were:

1. An open cut, with but moderate depth of excavation.
2. A comparatively short distance from sea to sea.
3. Fair harbors on either side.
4. Proximity to a well-constructed railroad.
5. Established communication, which exists with the principal ports of the world.

The disadvantages to offset these were:

1. The prevailing calms of Panama Bay.
2. The want of materials for the purposes of construction.
3. The large annual rainfall.
4. The character of the swamp lands in certain portions of the canal-line.
5. The amount of tunneling required for the feeder.
6. A doubt as to the sufficiency of the water-supply at all times.
7. The necessity of introducing a viaduct.
8. The unhealthfulness of the country.
9. The general objections which apply to all lock-canals.

A further discussion of the Panama route will be given in connection with the Nicaragua and Napipi routes.

The *San Blas Route*, as proposed, starts from San Blas Bay, on the Atlantic side, and has its Pacific terminus at the mouth of the Bayamo, or Chepo, River.

This was a favorite route with several explorers, the isthmus being here only 30 miles in width. Surveys were made by Mr. Kelley and by a party under Captain Thomas O. Selfridge, U.S.N.; also a survey by Mr. Wyse.

The profile across this section shows a dividing ridge of over 1,100 ft., while for nearly 10 miles there is a constant elevation of over 300 ft.

Mr. Kelley's scheme comprehended here a sea-level canal, with a tunnel 7 miles in length, piercing this dividing ridge. He proposed to utilize the Bayamo River for 10 miles of its course, thus reducing the actual line of canal to only 20 miles, of which 13 would be open cutting.

The tunnel, as proposed by this scheme, was to have the following dimensions: Length, 7 miles; width at water-surface, 80 ft.; height of tunnel, from bottom of canal to top of arch, 140 ft.; depth of water, 28 ft.

The route, as here proposed by Captain Selfridge, varied slightly from this, and required a tunnel 8 miles in length.

The chief objection to this route was the necessity of tunneling.

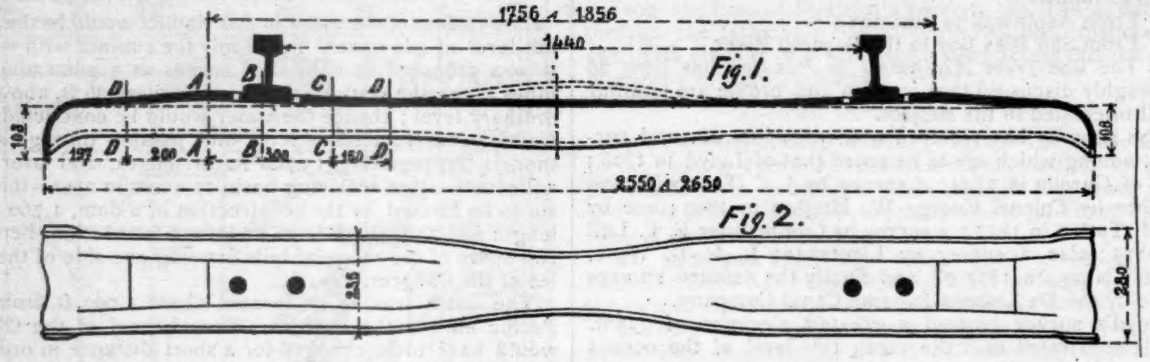
The insufficient water-supply precluded the idea of a lock-canal. This was also among the routes presented for the consideration of the Paris International Canal Conference in 1879.

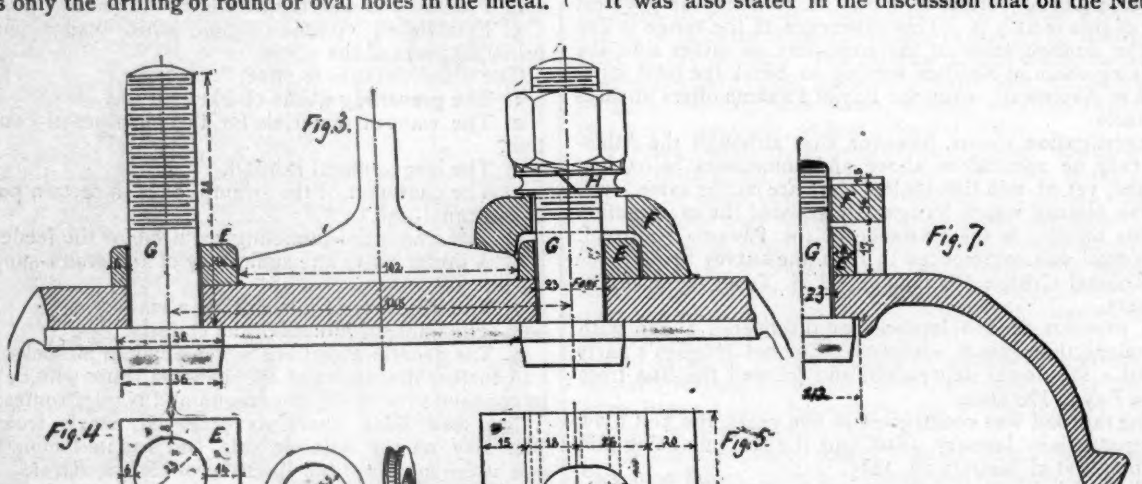
(TO BE CONTINUED.)

METALLIC TIES IN EUROPE.

IN the debate on the use of metallic ties in the International Railroad Congress in Paris, it was stated by the representative of the Belgian State Railroads that the greatest difficulty experienced on that line was with the cracking or splitting of the ties. These cracks generally commenced at the angles of the square holes made in the tie to receive the chairs which hold the rail in place. It was also stated that the trouble and expense of making these holes was considerable.

In answer to this, M. Kalff, of the Netherlands State Railroads, presented a plan for fastening the rails to the ties, which has been adopted on these lines, and which requires only the drilling of round or oval holes in the metal.





These plans, with drawings of the tie used, are shown in the accompanying engravings. In these, fig. 1 is a longitudinal section of the tie, and fig. 2 a view of the tie from below; fig. 3 is a section on a larger scale of a portion of the tie, showing the plan adopted for fastening the rail. This, it will be seen, is done by bolts. The two bolts *G G* have a bearing with their heads in the recess formed on the underside of the tie. These bolts pass through the tie and through square washers or plates, *E E*, which abut against the rail and keep it from moving laterally, and also through clips *F F*, which bear at one end upon the tie and at the other end upon the foot of the rail, holding it down in place. Each of the bolts *G G* has a single nut, which screws down upon a nut-lock *H*. Fig. 4 is a plan of the square plate or washer *E*; fig. 5, a plan of the clip *F*, while fig. 6 shows the nut-lock *H*; fig. 7 is a half section of the tie at *B B*, fig. 1 also showing the fastenings. Fig. 8 is a cross section on the line *A A*, fig. 1; the sections of the tie on the line *C C* and *D D*, fig. 1, are very similar to that shown in fig. 8.

M. Kalff stated that with these fastenings there had been no difficulty in keeping the rails tight and in place; and while there had been some trouble arising from the cracking of the ties, it had not been by any means so great as was experienced on the Belgium roads. Such breakages as had occurred he was inclined to attribute rather to the fact that the ties heretofore used had been somewhat too light in section, or perhaps had not been properly designed. It was not necessary, however, for that reason to abandon the metallic tie, but experiments should be continued until the best section was ascertained by practice.

It was also stated in the discussion that on the Netherlands State Railroads the cost of maintaining the road in good condition with metallic ties was somewhat greater than with wooden ties. The time had been too short, however, to decide this point fully, and their use would be continued for a number of years; that is, until the cost of the renewals begins to have its effects on the expense of maintenance. In this way only can a full and final settlement of the question as to the relative cost of maintenance with iron and wooden ties be reached.

UNITED STATES NAVAL PROGRESS.

THE Naval Appropriation Bill, as reported by the House Committee, authorizes the construction of four new ships of large size. One of them is to be built on the Pacific Coast and one on the Gulf of Mexico or waters tributary thereto, provided contracts can be made at a reasonable cost; but all or any of them may be built in the navy yards, provided no proper bids are received from contractors. One of the four is to be an armored cruiser of about 7,300 tons displacement and 20 knots speed, to cost $2,750,000; the other three are to be sea-going battle-ships of 8,500 tons displacement, to carry guns and armor of the heaviest kind, to have the highest speed, coal endurance and manœuvring powers possible, and to cost $4,000,000 each.

Other appropriations include $30,000 for testing the Ericsson submarine gun; $25,000 for a new proving-ground on the Potomac River; $145,000 for the Washington ordnance shops; and $2,500,000 for the armament of vessels now building.

Such amendments as may be made to the bill in the House will probably change its general character very little; the Senate is an uncertain body, however, and considerable changes may be made there.

The battle-ships proposed by this bill will be the heaviest vessels yet undertaken for the Navy.

THE BARBETTE TURRETED SHIP "PURITAN."

Reference has before been made to the plans adopted for the completion of the *Puritan*, originally begun as a double-turreted ship of the *Monitor* class. These plans were prepared in the Navy Department some time ago. The accompanying illustrations, showing a general view and deck plan of the vessel, with the description given below, are taken from the report of the Bureau of Construction and Repair.

By the new plans adopted for the *Puritan*, the armament and armored protection are greatly increased, and the quarters of officers and crew made far more comfortable and roomy than originally proposed.

No changes are made in the principal dimensions, which are as follows: Length on load line, 291 ft.; breadth, extreme, 60 ft. 1½ in.; mean draft, 18 ft. 2¼ in.; displacement, 6,060 tons; tons per inch, 33.64.

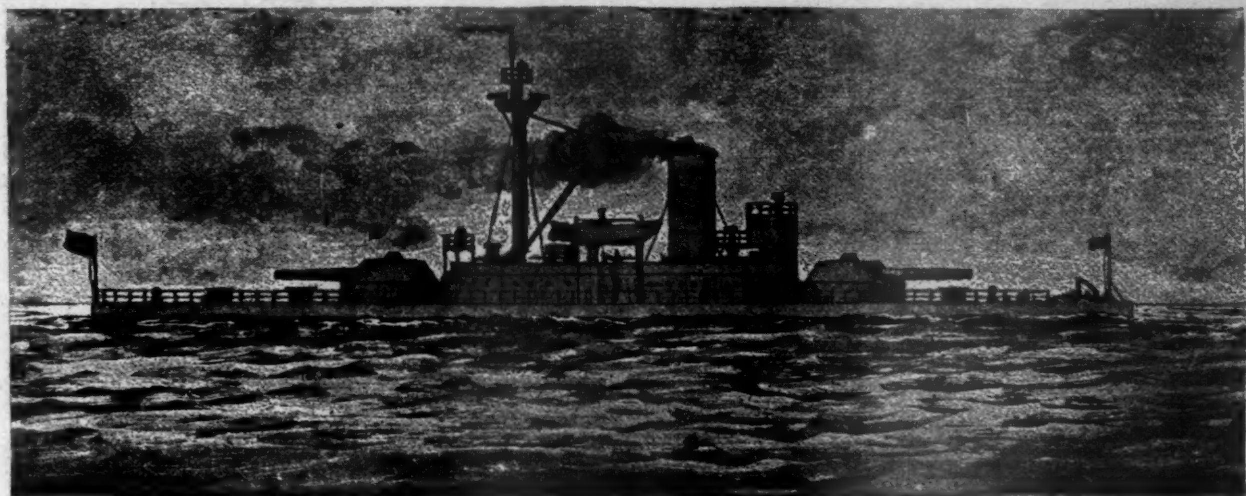
The change consists in substituting for the four 10-in. guns in roller-base turrets, four 12-in. guns in barbette turrets, and instead of the hurricane-deck a superstructure is built between the barbette-turrets.

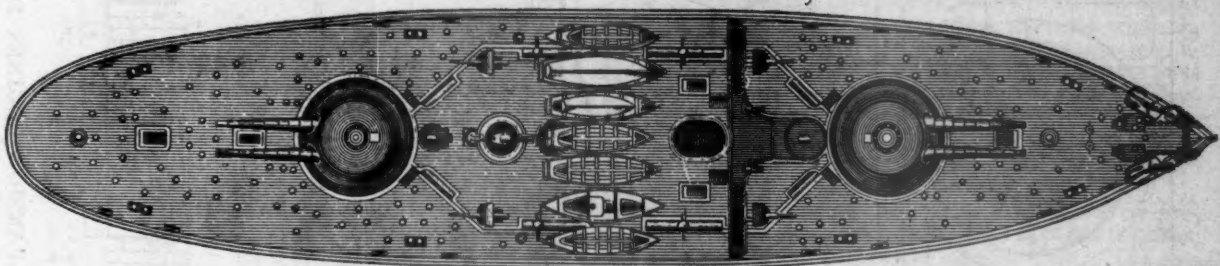
The axes of the 12-in. guns are 10 ft. 6 in. above the water, which will permit their being fought in much heavier weather than was possible with the roller-base turrets. The revolving parts of the turn-tables, the hydraulic machinery for turning them, and the loading and elevating gear of these guns will be protected by fixed barbettes having steel armor 14 in. thick backed by 8 in. of wood, two 20-lb. plates, and a system of horizontal and vertical girders. These guns are inclosed in sloping turntable shields of steel 8 in. thick. There are six 4-in. rapid-fire rifles, two on the main deck protected by 4-in. armored barbettes built in as part of the superstructure, and four on top of the superstructure protected by shields.

The rest of the battery consists of two 6-pounders, four 3-pounders and four 37-mm. revolving cannon, two of them in the military top.

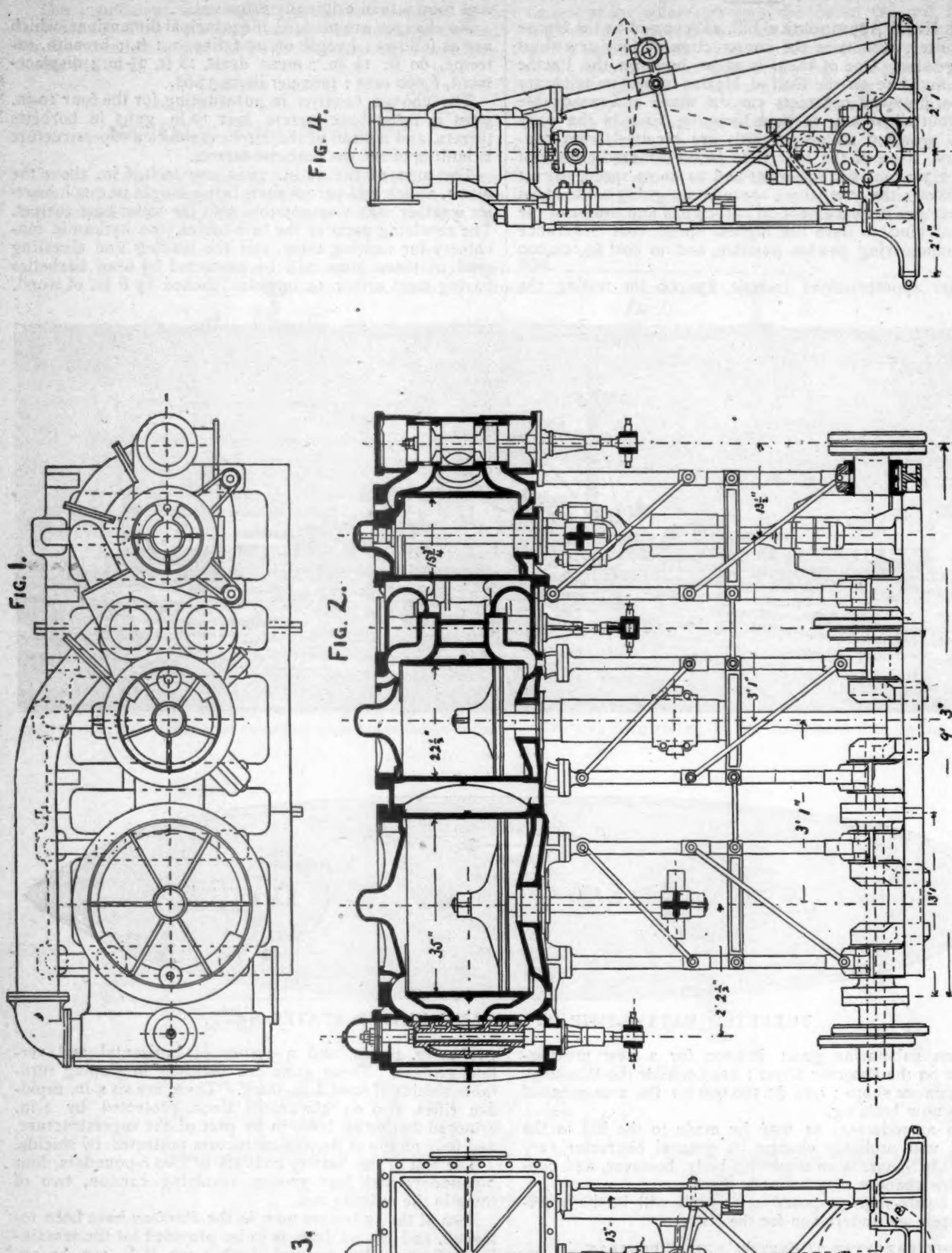
Two of the 10 boilers now in the *Puritan* have been removed, and forced draft is to be provided for the remaining boilers. With natural draft 3,000 H.P. can be obtained with a corresponding speed of 12 knots, and with forced draft 4,000 H.P., with a speed of 13 knots.

The hull is protected by a belt of armor 5 ft. 7 in. deep, 14 in. thick to a point below the water-line, and thence tapering to 6 in. at the armor shelf for a length of 160 ft., protecting the engines, boilers, magazines, shell-rooms, etc. Immediately forward and abaft these points the belt is reduced to 10 in. in thickness for a length of 20 ft., and at the ends it is reduced to 6 in. This armor is strongly





TURRETED BATTLE-SHIP "PURITAN," UNITED STATES NAVY.



TRIPLE-EXPANSION ENGINES FOR GUNBOATS 5 AND 6, UNITED STATES NAVY.
DESIGNED BY THE BUREAU OF STEAM ENGINEERING; GEORGE W. MELVILLE, CHIEF OF BUREAU.

backed by wood lagging and a system of rigid frames and girders. Over the main-deck there are two thicknesses of 1-in. deck armor. There is a conning-tower, protected by 10 in of steel armor, situated immediately abaft the forward barbette. This contains the steering-wheel, mechanical telegraphs, speaking-tubes, etc. For ordinary

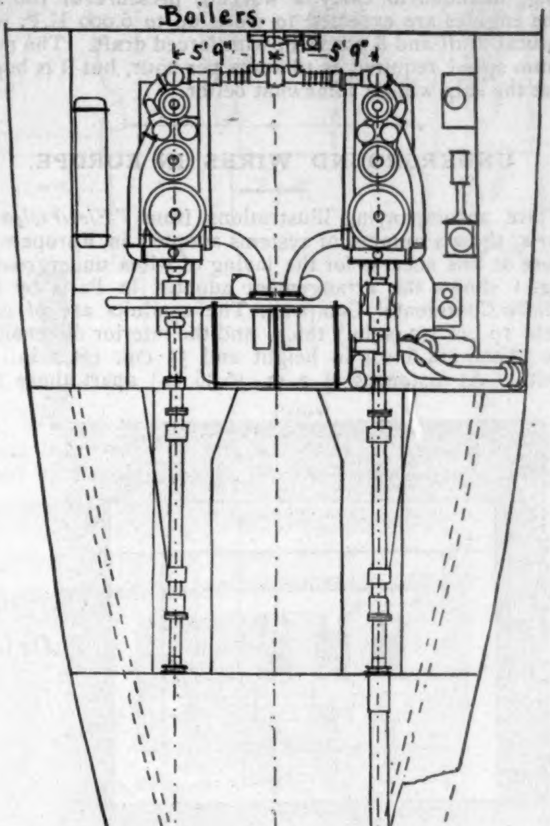


FIG. 5.

use there is a pilot-house of wood fitted with steering-wheel, chart table, speaking-tubes, etc.

The Captain has a cabin in the superstructure between the barbettes, adjoining which are his state-room, bath-room, pantry and office. Forward of this are eight ward-room state-rooms opening into a passage which, just forward of these rooms, widens out into a commodious dining-room, extending from side to side; forward of this again are four more ward-room state-rooms, making 12 in all. Forward of these again are the galley, the officers' water-closets and bath-room and the crew's water-closets and wash-room. These quarters, well lighted and ventilated, will be comfortable in all seasons. On the after berth-deck are the junior officers' quarters, having 10 berths, near which are the pantry, bath-room and lavatory. In the same part of the vessel are the quarters for the warrant officers, having state-rooms for the gunner and carpenter opening into a mess-room, adjoining which is the pantry. Just forward of these is a large compartment which is used as berthing space for the crew. Opening into this space is the Executive Officer's office and Paymaster's office. There is a passage on each side connecting the forward and after berth-decks, and opening into the passage on the starboard side are the armory and navigator's office, and on the port side is the crew's lavatory. Forward there is a large sick-bay, adjoining the dispensary and bath-room for the sick. The remainder of the forward berth-deck is given to the crew, who have on this vessel more room than on most of the modern cruising vessels, giving a most favorable outlook for the health, comfort and contentment of the crew when contrasted with the stifling and crowded quarters of the old monitors.

There are large centrifugal fans for supplying fresh and exhausting foul air, while the system of drainage is such as exists in double-bottom ships of this class. A most complete system of electric lighting is provided not only for internal illumination, but for the side and masthead lights and search-lights. The ship can carry 450 tons of coal at her normal draft.

There is a military mast 20 in. in diameter and 50 ft. above the superstructure deck, placed abaft the smoke-pipe, out of the line of fire for signal purposes, and fitted as an uptake for exhaust ventilation from the engine-room. There are two tops, one for search-lights and the other for revolving cannon. Two steel booms for handling boats are attached to the mast.

The *Puritan* is now at the New York Navy Yard, where the work on her completion is being pushed forward as rapidly as possible.

ENGINES FOR THE 1,000-TON GUN-BOATS.

The accompanying illustrations, taken from the report of the Bureau of Steam Engineering, show the triple-expansion engines designed by the Bureau for the new gun-boats of 1,000 tons displacement, for which contracts have been let. These vessels were described in the March number of the JOURNAL; it may be said briefly that they are 190 ft. long, 32 ft. breadth and 12 ft. mean draft. The description of the engines given below is from the report just referred to.

The new 1,000-ton cruisers or gun-boats will be propelled by twin-screw, vertical, triple-expansion engines, placed in a common water-tight compartment. The two sets of engines are independent except that there is only one condenser for both. An auxiliary condenser with a capacity equal to all the auxiliary machinery, except the main air and circulating pumps, is to be supplied. This will have an independent, combined air and circulating pump. The main condenser will have air-pumps and a circulating pump similar in general features to those for the *Monadnock*.

The valves for the high-pressure and intermediate-pressure cylinders will be plug pistons grooved, one for the high-pressure and two of the same for the intermediate-pressure, while the low-pressure cylinders will have double-ported slide valves, all worked by Stephenson double-bar links.

The boilers will be of the low cylindrical type, all in one water-tight compartment.

Evaporators, distillers, auxiliary machinery, etc., are provided as in the larger ships. Provision is made for heating the feed-water.

The following are the dimensions of the machinery: Cylinders, $15\frac{3}{4}$, $22\frac{1}{2}$ and 35 in. in diameter by 24 in. stroke. The indicated power is 1,600 H.P. at 200 revolutions per minute and 160 lbs. working pressure. Piston-valves for high-pressure and low-pressure cylinders, $7\frac{1}{2}$ in. diameter. Diameter of crank-shaft journals and crank-pins, 7 in.,

with 3½ in. axial holes. Cranks at 120° and sections of shafts interchangeable. The line, thrust and propeller shafts will be about 7 in. diameter, with 3½ in. axial holes.

Cooling surface in main condenser about 2,246 sq. ft. Diameter of air-pumps, 13½ in.; stroke, 12 in. Capacity of circulating pump, 3,000 galls. per minute.

There will be two boilers 9 ft. 9 in. in diameter by about 16 ft. 10 in. long, with three corrugated furnaces of 36 in. diameter in each. Thickness of boiler sheets, ¾ in. Total grate surface, 100 sq. ft.; total heating surface, 3,360 sq. ft. Forced draft will be by closed fire-room.

In the illustrations given fig. 1 is a plan of one of the engines; fig. 2, a longitudinal section; fig. 3, an end-view looking forward; fig. 4, an end-view looking aft; fig. 5, a plan showing the position of the engines, etc., in the ship; figs. 6, 7 and 8 are cross-sections, showing respectively the position of the twin screws, the boilers and the engines.

The engines for the practice vessel for the Naval Academy are of very similar design and construction in all respects, the main difference being that they are smaller, having

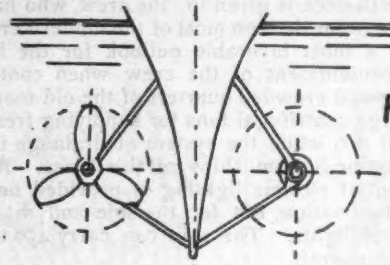


FIG 6.

cylinders 13½ in., 21 in. and 31 in. in diameter and 20 in. stroke. They are expected to develop 1,300 H.P. at 240 revolutions per minute and 160 lbs. working pressure. This ship will have two boilers, each 8 ft. 8 in. in diameter and 17 ft. long, with two corrugated furnaces 39 in. in diameter.

LAUNCH OF THE NEWARK.

The cruiser *Newark*, which was successfully launched at the Cramp Yards in Philadelphia, March 19, was among the first of the large cruisers ordered for the Navy, but her completion has been delayed by different causes. The *Newark* is about the same size and general dimensions as the *Baltimore*, but has been built on different lines, her design being entirely due to the Navy Department.

The principal dimensions of this vessel are as follows: Extreme length, 329 ft.; length on load water-line, 310

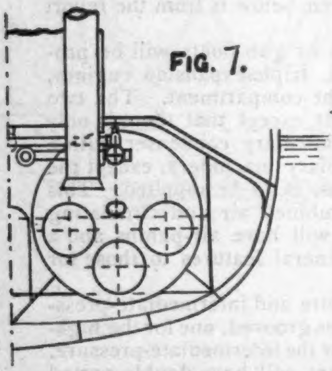


FIG. 7.

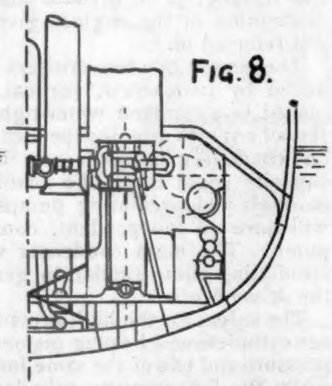


FIG. 8.

ft.; molded breadth, 49 ft.; extreme breadth, 49.14 ft.; depth from flat keel plates to under side of spar-deck, 31.80 ft.; mean draft, 18.825 ft.; displacement to load water-line, 4,083 tons; tons per inch at load water-line, 24.96; area of load water-plane, 10,481 sq. ft.; area of immersed midship section, 807.23 sq. ft. The *Newark* will have three masts, and the area of the sails will be 11,932 sq. ft.

The battery will consist of ten 6-in. rifled cannon mounted on central pivot carriages. None of these guns will be mounted on the forecastle or poop-deck, but will be carried underneath each of these decks. There will also be a heavy secondary battery of rapid-fire and machine guns.

The motive power will be furnished by two triple-expansion engines, one to each screw, having cylinders 34 in., 48 in. and 76 in. in diameter and 40 in. stroke. There are four boilers 13 ft. 6 in. in diameter and 19 ft. 6 in. long, intended to carry a working pressure of 160 lbs. The engines are expected to work up to 6,000 H.P. with natural draft and 8,500 H.P. with forced draft. The maximum speed required is 18 knots per hour, but it is hoped that the ship will do somewhat better.

UNDERGROUND WIRES IN EUROPE.

THE accompanying illustrations, from *l'Electricien* of Paris, show a number of systems adopted in Europe with more or less success for the laying of wires underground. Fig. 1 shows the arrangement adopted in Paris by the Edison Continental Company. The conduits are of concrete 10 cm. (3.94 in.) thick, and the interior dimensions are 37 cm. (14.6 in.) in height and 55 cm. (21.7 in.) in width. At distances of 2 m. (6.56 ft.) apart there are

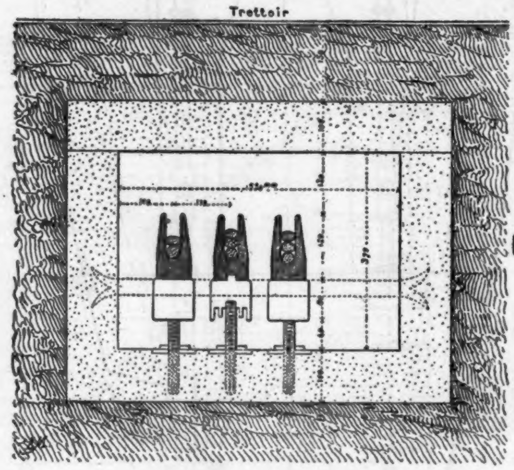


Fig. 1.

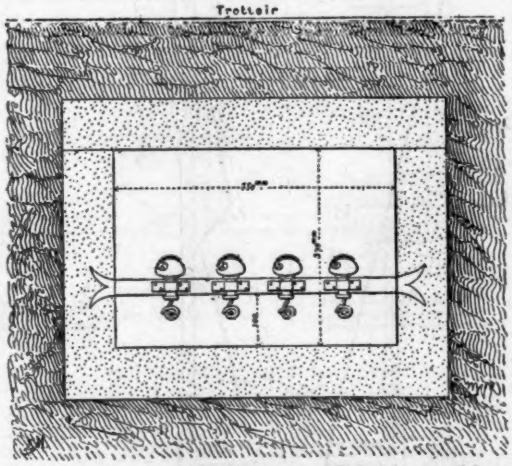


Fig. 2.

placed in the bottom of the conduits bars of iron having each four threaded holes spaced 11 cm. (4.33 in.) apart, and intended to carry the insulators. These are shown in figs. 2, 3 and 4, and are of enameled porcelain having below a hole and screw by which they are fastened upon the iron tires. On the upper side of the insulator proper *P* is a fork *F* of galvanized iron intended to carry the copper cables, and having on each side a small lug, as shown in figs. 3 and 4. These lugs are intended to hold the clamps or yokes which hold the cables in place, as shown in figs. 4 and 5. At a short distance from each insulator is placed a transverse bar of iron screwed in the sides of the conduit, and carrying porcelain insulators with a short curve piece of galvanized-iron wire attached, as shown in figs. 2 and 6. Each one of these can carry two conductors, and

the wires serve to measure the differences in potential at certain points.

The conduits are placed under the sidewalks at a depth of about 15 cm. (5.9 in.). At the street-crossings there are

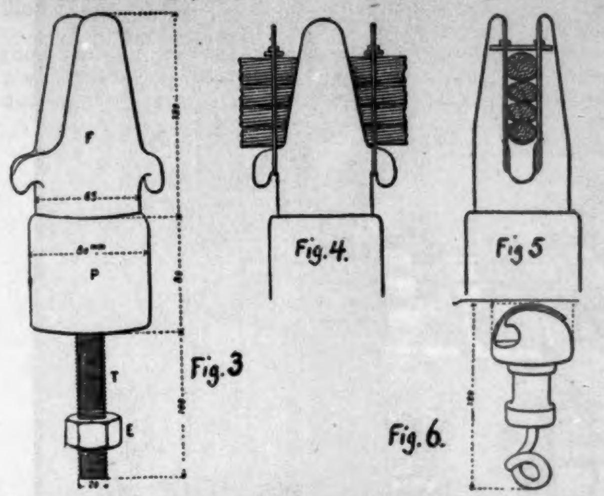


Fig. 3 Fig. 4. Fig. 5 Fig. 6.

placed little wells or pits 6 or 7 m. in depth, which are joined by a cross conduit. In the smaller streets, where

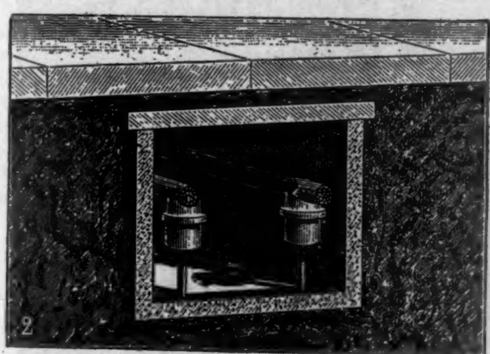


Fig. 7.

Fig. 8.

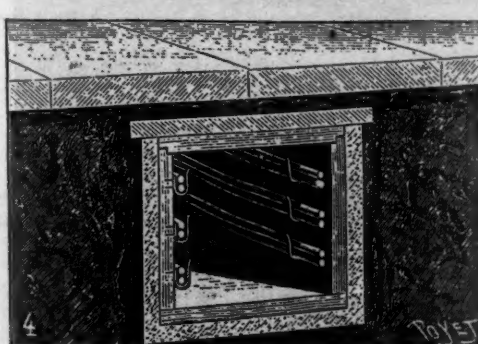


Fig. 9.

the City Government has given the Company only a very contracted space, use has been made of square conduits of pottery, in which the insulators are secured in very much the same way.

The Society for the Transmission of Electric Power has three central installations in Paris, and has used conductors of copper resting upon porcelain carriers, as shown in fig. 7. They are kept in place by means of iron bars held by bolts. The conduits are very similar to those used by the Edison Company.

The Victor Popp Company uses a system entirely different from the other two. Iron pipes 20 cm. (7.97 in.) in diameter, similar to those used for distributing power by compressed air, are placed under the sidewalks with man-holes at intervals. The pipes are joined by bolting flanges with rubber packing. The cables are simply placed in the pipes, as shown in fig. 8. This plan, although very simple, has some inconveniences. The cables are drawn into the pipes by means of the cords left in when they are laid, and, no matter what precautions are taken, they are often damaged. In fact, the disadvantages have been found so great as to neutralize the cheapness in first cost.

For the municipal service at low tension in Paris, conduits of concrete are used in which are fixed wooden frames carrying supports of iron. These wooden frames are about 1.50 m. (4.92 in.) apart. The top piece of the wooden frame is movable, and can be put down rapidly. The cables employed are well covered with rubber. This system is shown in fig. 9. For the high-tension system the same conduits are used, but the cables rest in wooden holders fixed in the conduit.

In Germany the Siemens System, which is shown in figs. 10 and 11, is used almost exclusively. The copper cables are covered with a thick coating of jute saturated with bitumen and rendered flexible by the addition of heavy oil. The cable is then covered by a lead pipe, then by another layer of jute and by two layers of wire rolled or wrapped one over the other in the same direction, the outer one covering the joints of the inner, and finally by a glazing which is intended to preserve the wire. These cables are

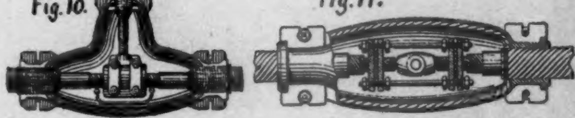


Fig. 10. Fig. 11.

placed directly in the ground, and are joined by junction boxes shown in figs. 10 and 11. The connection having been made, the junction box is filled with melted tar and the opening is then closed by a cover screwed on.

The principal system employed in London is the Crampton plan. In this the conductors used are of a square section, presenting much stiffness, so that the supports can be placed a long distance apart. They are carried by insulators of glass, which are joined to others fixed upon transverse girders by light bars. At intervals man-holes per-

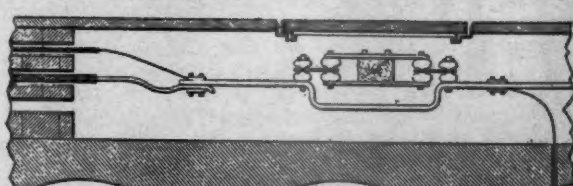


Fig. 12.

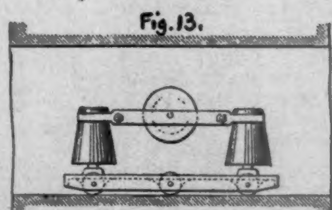


Fig. 13.

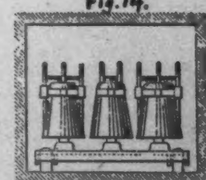
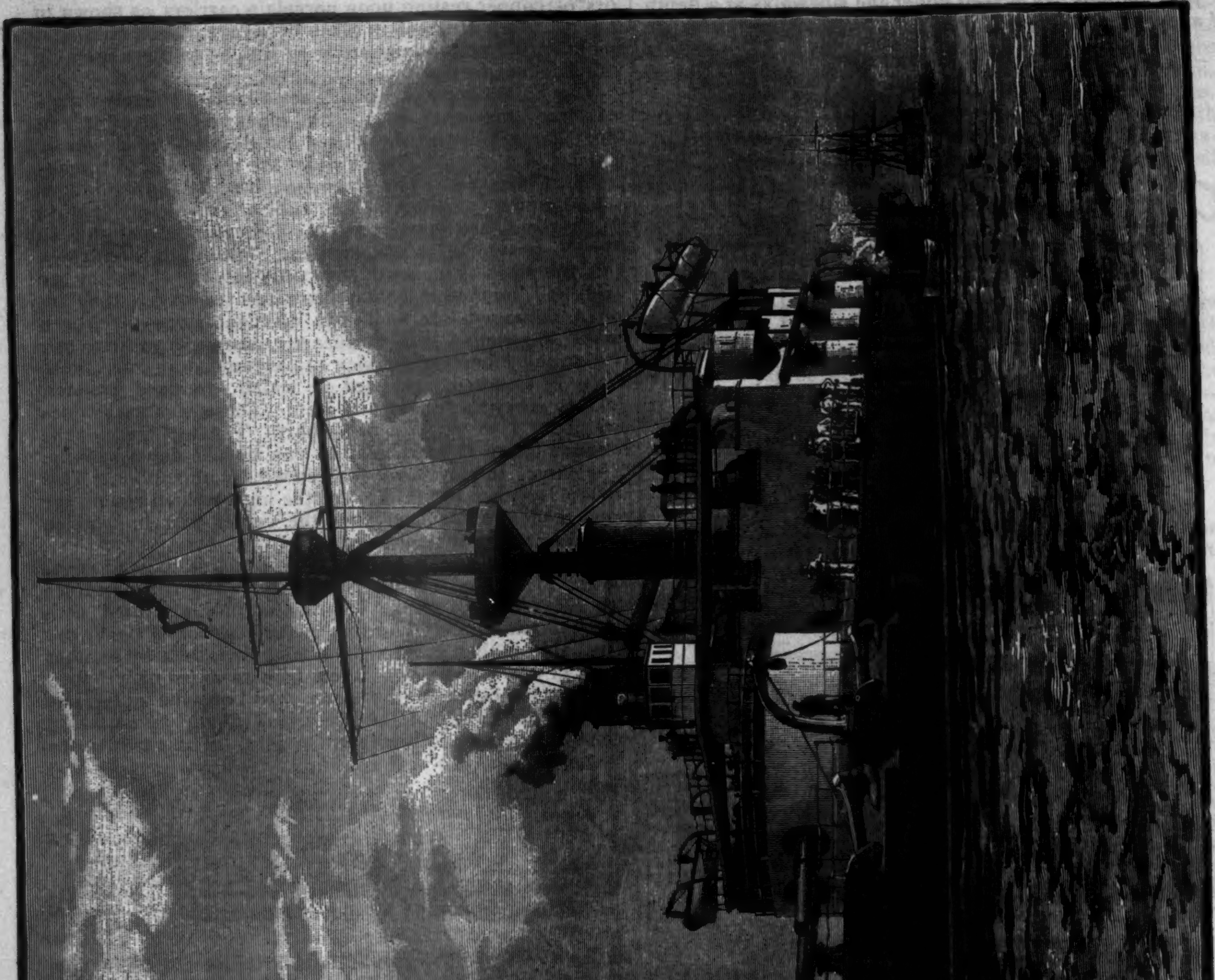


Fig. 14.

mit inspection. The feeders are wrapped in rubber, and are drawn through iron tubes. This arrangement is shown in fig. 12. As it is not always convenient to employ fixed carriers, Mr. Crampton has designed a little car,



BATTLE-SHIP "TRAFALGAR" FOR THE ENGLISH NAVY.

which is shown in figs. 13 and 14, upon which the insulators are placed. Around them is fixed an iron band which carries a pulley, upon which the copper conductor rests. Where this is used the cables can be drawn directly upon their supports from the end of the conduit.

The St. James Electric Light Company uses a copper conductor of rectangular section composed of copper plates joined together in convenient number. The conductors thus formed rest in square slots made in a carrier

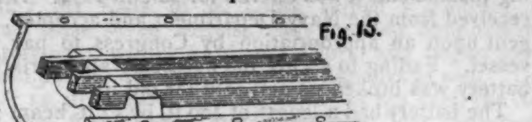


Fig. 15.

Fig. 16.

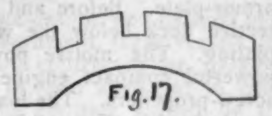


Fig. 17.

of glazed porcelain. These carriers or bridges are placed in a cast-iron conduit of the form shown in figs. 15 and 16, covered by a top which is bolted on. Fig. 17 shows one of the carriers or bridges. The conduit is made in sections about 3 ft. long, which are joined together by flanges and bolts with suitable packing. This makes a very strong and tight arrangement, but has not yet been very extensively introduced.

The House-to-House Company in London uses cables placed in iron pipes. These pipes run into man-holes of the special form shown in fig. 18. The man-hole boxes

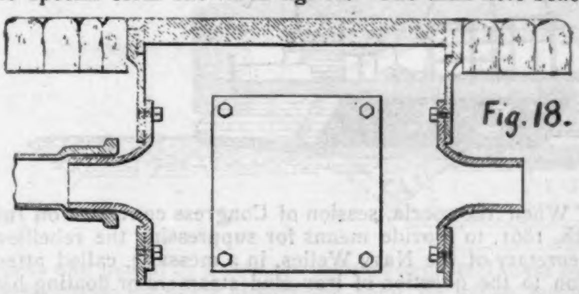


Fig. 18.

are of cast iron, but are open at the bottom, the floors being made simply by sand tamped down well. The cover is movable, and is on a level with the street or sidewalk. This system has been in use about a year, and so far with very good results.

The Calendar Bitumen Company has introduced two different systems. In the first one, which is in use in Liverpool, the cables are placed in cast-iron troughs, in

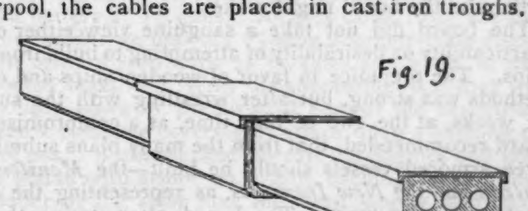


Fig. 19.

which a bituminous composition is poured hot and becomes solid in cooling. This, of course, can only be applied when it is not necessary to move the cables after they are once put in place. In London, the same Company has employed the form of conduit shown in fig. 19. This conduit is made of bitumen pierced with a number of holes as shown, and is in sections about 3 ft. in length. The joints are made by heating the ends of the sections and pressing them together, and then surrounding them with a regular box, which is made tight by pouring hot bitumen into the joints. The advantage claimed for this arrangement is that the cables are preserved from all dampness.

So far as experience has yet shown, preference is given to the system employed in Paris; but it is admitted that further use is necessary to obtain a system which will be thoroughly satisfactory.

THE ENGLISH BATTLE-SHIP "TRAFALGAR."

THE accompanying illustration, which is reproduced from the *Illustrated London News*, is a general view of the English battle-ship *Trafalgar*, one of the heaviest and most powerful war-ships afloat. This vessel was launched in 1887, and is now just completed and ready to go into commission. She is built entirely of steel, and in her design great pains was taken to avoid the structural weakness which has been a defect of some other English battle-ships.

The dimensions of the *Trafalgar* are as follows: Length, 345 ft.; breadth, 73 ft.; displacement, 11,940 tons; indicated H.P., 12,000; draft, 27 ft. 6 in. The armor belt at the water-line extends to a length of 230 ft. amidships, and is 20 in. thick at the center, tapering off slightly to the ends, where it encounters and combines with bulkheads of 14-in. armor, thus forming with them a sort of lower citadel, this being decked over with 3-in. steel so far as the ends of the main or upper citadel. The same 20-in. plates that form the walls of this lower portion are continued upward as the walls of the upper citadel, which is 193 ft. in length, but the thickness of the plates is reduced to 16 in. The parabolic ends or bulkheads of the upper citadel are protected with 18-in. armor, as are also the turrets which spring from within its angles. The armor, both of sides and bulkheads, is backed with about 18 in. to 20 in. of teak, and behind this again is a strong inner steel skin 2 in. thick. The plates are compound, having wrought-iron backs with a steel face. Those on the sides taper, or are beveled off beneath the water-line to an edge of only 8 in. The teak is dressed and cut away on the surface so as to fit the plates precisely. The plates at the ends of the main citadel are secured by the bolts being passed through large holes left at intervals in the bed of the turret, otherwise they could not be worked in. Over the whole of the main or upper citadel is a 3-in. steel deck; upon this is built a central-box battery for eight 5-in. breech-loading guns. The side walls of this are of light plates, but the ends are protected from raking fire by 6-in. armor and a backing of teak. Upon the spar deck covering this battery the boats will be stowed and a number of machine guns and quick-firing guns will be mounted, the latter comprising eight 6-pounder Hotchkiss and eleven 3-pounders of the same nature. The ends of the vessel are protected beneath the water-line by a steel deck 3 in. thick, extending from the 14-in. bulkheads before alluded to to the ram at one end and to the sternpost at the other. Thus the vitals of the ship are completely protected by armor-plates from end to end. The number of torpedo tubes will, we understand, be four—one in the bows, one astern and two diagonally from the broadside. The turrets will be revolved by hydraulic power.

Each turret contains two 67-ton breech-loading steel guns, which will be loaded and worked by hydraulic power, being on the disappearing system, hinged upon huge levers, so that they rise for firing within rectangular slots, and descend for the loading position beneath the armored deck.

The dimensions of one of these guns are as follows: Total length, 36 ft. 1 in. (433 in.); length of bore, 405 in.; diameter of bore of gun, 13.5 in.; diameter of powder chamber, 18 in.; length of powder chamber, 66.5 in.; capacity of powder chamber, 17,100 cubic inches; weight of gun, 67 tons; full charge, 520 lbs. prismatic brown powder; estimated muzzle velocity, 1,960 foot-seconds. It is entirely of forged steel, and the disposition of the breech-piece and of the covering hoops have been designed so as to break joints and cover every conceivable spot which might be a source of weakness.

The highest speed attained by this ship is 16½ knots an hour. The coal bunkers can carry 1,200 tons of coal, and with that supply the vessel can steam 6,500 knots. The coal is so carried as to give additional protection to the

engines. The hull is divided by 27 water-tight bulkheads into numerous compartments. The steering gear is placed below the armored deck.

The estimated cost of the ship, ready for service, was about $4,600,000. A sister ship, the *Nile*, is also ready for service.

THE DEVELOPMENT OF ARMOR.

By First Lieutenant Joseph M. Califf, Third U. S. Artillery.

(*Continued from page* 163.)

XI.—IN THE UNITED STATES.

When the necessity for building iron-clad ships of war was forced upon the American people at the outbreak of the rebellion, the development of armor was still in its infancy in Europe, while in the United States, if we except the Stevens Battery, a beginning had not yet been made. France and England had built iron-clad floating batteries, whose value had had ample proof under hostile shot, and in carrying out the policy of creating an iron-protected fleet France already had two sea-going armored fighting ships afloat, while England was pushing toward completion the first of her magnificent array of armor-clads. Neither were the other maritime powers of Europe asleep.

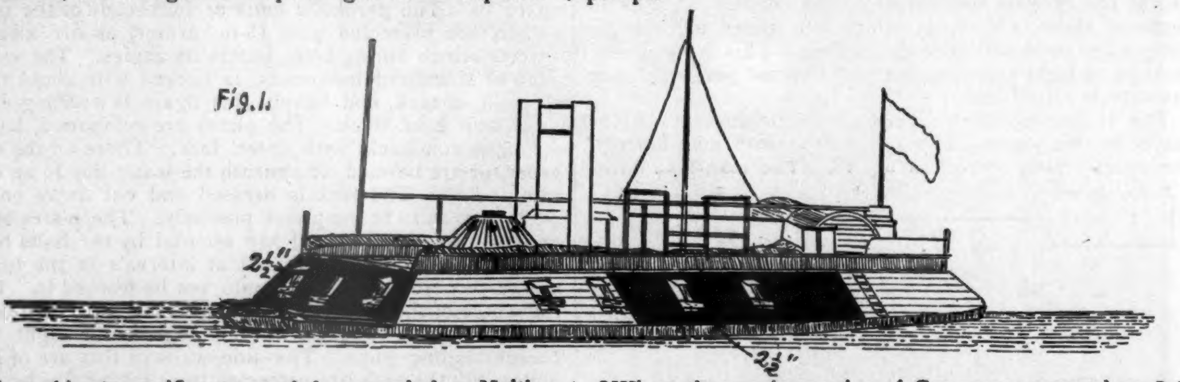
At this time the whole question of armor—of its manufacture, its distribution, its proper thickness was in a transition state. Although the first iron-clads built were of the then existing type of fighting ships, yet the idea of putting guns in a revolving armored turret, upon a vessel of low free-board, was not a new one. Its advantages had been discussed in English naval circles fully a twelvemonth before the *Monitor* was decided upon. As a matter of fact, work on a sea-going armored turret vessel had been begun by the Danish Government before the contract for the building the *Monitor* had been signed.

Whether it was Captain Ericsson, Captain Coles or Mr. Timby who first conceived the idea of a revolving turret for war-ships or batteries, it is certain that to the former belongs the honor of being the first to push to completion a vessel of this description. Not only this, but it appears that as early as 1854 he submitted to the Emperor Napoleon the design for an iron-clad battery with a semi-spherical turret, showing that with him the idea was by no means a new one when he designed the *Monitor*.

No account of the development in the United States of armor-clad ships would be complete without some mention of what was known as the *Stevens Battery*. One cannot to-day read a description of this vessel without the feeling that it was an invention born before its time; for we shall find in any fleet of modern war-ships nearly every device employed by the inventor of the Stevens Battery—independent screws, inclined armor, an all-around fire, a protective deck, and guns manipulated by machinery. In 1842 Mr. Robert L. Stevens, of Hoboken, N. J., was encouraged by the Government to build an iron-plated steamer or battery, to be shell-proof and driven by screws. Work upon it was not actively begun until 1854. Upon his death, two years later, his brother, Edwin A. Stevens, continued the work. The battery was unfinished at the outbreak of the rebellion, and the offer of its owner to push it to completion and turn it over to the Government, to be paid for only after it had proved successful, was not accepted. Mr. Stevens continued work upon it, and at his death, in 1868, willed it to the State of New Jersey, together with a large sum of money for its completion. This proving insufficient, it was offered for sale in 1874. A bid was received from the Navy Department and accepted, contingent upon an appropriation by Congress to pay for the vessel. Failing to secure the necessary appropriation, the battery was broken up and sold for old iron.

The battery had a length of 420 ft. by 52 ft. beam; a continuous water-line belt of armor made up of solid slabs of iron 3½ in. in thickness; a 180-ft. central casemate, covering the machinery, whose sides and ends had a slope of 60° with the perpendicular, and were covered with 6¾-in. armor-plate. Before and abaft the casemate was a protective deck below the water-line, provided with 1½-in. plating. The motive power was provided for by four powerful compact engines to each of two independent screw-propellers. The loading and training of the guns was to be done by machinery, and the guns, instead of being within the casemate, were in barbette on top of it. Provision was made for partially submerging the battery for action by the admission of water into compartments, which could be quickly emptied again by powerful steam pumps.

Fig. 1.



When the special session of Congress convened on July 4th, 1861, to provide means for suppressing the rebellion, Secretary of the Navy Welles, in a message, called attention to the question of iron-clad steamers or floating batteries, but with no very hearty recommendations on the subject beyond the suggestion that a board of officers be appointed to inquire into and report upon the matter. A month later Congress authorized the Secretary of the Navy to appoint such a board to investigate the whole subject, examine plans and make recommendations, and appropriated a million and a half to carry out such recommendations as the board might make.

The board did not take a sanguine view either of the practicability or desirability of attempting to build iron-clad ships. The prejudice in favor of wooden ships and of old methods was strong, but after wrestling with the subject six weeks, at the end of that time, as a compromise, the board recommended, that from the many plans submitted, three armored vessels should be built—the *Monitor*, the *Galena* and the *New Ironsides*, as representing the three most promising types. The board, after stating the objections to iron-clad ships and the claims put forth in their behalf, took occasion to say: "We, however, do not hesitate to express the opinion, notwithstanding all we have heard or seen written on the subject, that no ship or floating battery, however heavily she may be plated, can cope successfully with a properly constructed fortification of masonry," and adds, "It is assumed that 4½-in. plates are the heaviest armor a sea-going vessel can safely carry."

Across the Potomac the Confederate authorities were more alive to the value of iron-protected vessels than they seemed to be at Washington. As early as May 8, 1861, Secretary of Navy Mallory urged the construction of iron-clad vessels, and a few weeks later work on the *Merrimac*, their first iron-clad, was begun.

It is generally supposed that the *Monitor*, the contract for whose construction was signed on October 4, was the first Federal iron-clad to take the field, or rather the sea, and that her fight in Hampton Roads was the first actual test of armor on this side of the Atlantic; but neither supposition is correct. While the Naval Board was as yet uncreated, the Quartermaster-General of the Army, in July, 1861, advertised for proposals to construct seven iron-clad gun-boats for service on the Western rivers, and on August 7, Mr. Eads, of St. Louis, signed a contract to construct these seven vessels, ready for their ammunition and armament, within 65 days. Work was begun soon after and pushed day and night, and Sundays as well. On October 12, in 45 days from the laying of her keel, the *St. Louis*, the first United States iron-clad, was launched, with engines on board, and this before the keel of the *Monitor* had been laid down; and these vessels received their baptism of fire some weeks before the latter vessel was turned over to the Government.

Owing to some changes in the design, and delayed payments on the part of the Government, these vessels, together with an eighth afterward contracted for, were not entirely finished until January 15, and were put in commission the next day. In the contract signed by the Quartermaster-General neither the thickness of the armor-plate nor the method of applying it was specified. This document says: "It is intended to protect the boilers and engines of these vessels with iron plates of sufficient thickness and placed in a suitable position to protect them from injury from the effect of shot and shell, for which purpose 75 tons of iron plating have been estimated."

These vessels were a little over 500 tons burden, flat-bottomed, 50 × 170 ft., and propelled by a single enclosed paddle-wheel a little forward of the stern. A casemate, in the shape of a square box, with sides and ends sloping at an angle of 45°, extending from the curve of the bow to that of the stern, contained the paddle-wheel, machinery and a battery of 13 guns. As they came from the hands of the builder we find the 75 tons of armor-plate disposed in the form of iron slabs 2½ in. thick and 11 in. in width, rabbeted together. With the supposition that they would only fight bows on, the forward ends of the casemate received a complete covering of armor upon a backing of 24 in. of oak. A short space abreast the engines and boilers was plated with armor on a 4-in. backing, leaving the remainder of the sides and the stern wholly unprotected. The pilot-house was at the forward end of the casemate, and plated with 2½-in. armor. Such were the first armor-clads built in the United States. In later constructions the armor was increased to 3 in. on the ends and 2½ in. on the sides, with an increased thickness of backing. The distribution of the armor upon these boats is shown in fig. 1.

While the Quartermaster-General of the Army was building a fleet of iron-clads for operations on the Western rivers, the naval authorities were not idle. As has been said, the Naval Board recommended the construction of three vessels of totally different types for service on the Atlantic coast. Of these but one was ever duplicated—the *Monitor*. Its timely appearance and the happy outcome of its conflict with the *Merrimac* made it at once a favorite, and it became the prototype of every iron-clad vessel built during the war upon the Atlantic seaboard, with two or three exceptions, and its name came to be used as a designation for a whole class of vessels whose central idea was, as has been said, that of a fort upon a raft.

The keel of the *Monitor* was laid in October, 1861, and the completed vessel was finished and turned over to the Government in the latter part of the following February. The general features of the *Monitor* are too well known to need detailed description. As to her armor, its distribution is shown in fig. 2.

The side armor was made up of five 1-in. wrought-iron plates, tapering to the bottom of the belt to 3 in., with a backing of 23 in. of oak. The deck was protected by two ½-in. plates of iron over 6 in. of oak planking. The side armor was blunt-bolted to the backing, the bolts coming a little short of the inner surface. The turret armor was made up of eight 1-in. plates without backing, and the turret was revolved by machinery about a central spindle. The two gun-ports were closed with iron pendulum shutters. The pilot-house was near the bow, and consisted of square iron logs 9 in. in thickness, notched at the ends and bolted together at the corners. A narrow space between the first and second layer of logs gave an all-around horizontal field of view. The turret-plates were held together by through bolts set up with nuts on the inside.

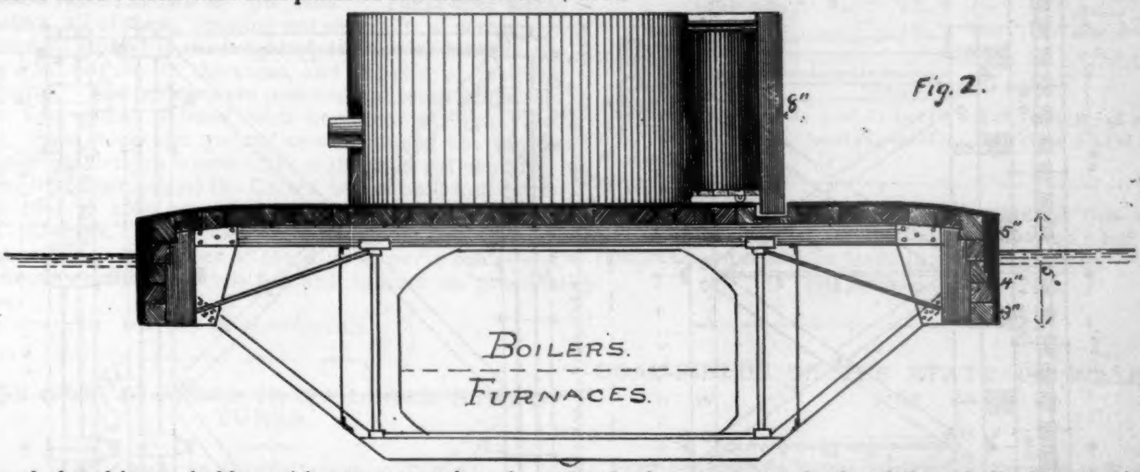


Fig. 2.

In the turret vessels that followed the *Monitor*, known as the *Passaic* class, the thickness of turret armor was increased to 11 in., and a cylindrical pilot-house was placed above the turret, composed of 8 in. of iron in 1-in. plates. The side armor was the same—5 in.—but the wood backing was increased to 39 in. In the *Puritan* and *Dictator*—sea-going turreted iron-clads—the side armor was increased to 6 in. and the backing to 42 in. The armor on the turret was increased to 15 in. in two drums, each made up of 1-in. plates, with segments of wrought-iron hoops, 5 in. in thickness, between the drums. In the *Kalamazoo* class of double-turreted monitors, the most powerful of any of the vessels constructed or planned during the war, the side armor was made up of two layers of 3-in. plates, backed by 30 in. of oak, strengthened at the water-line by iron stringers let into the backing a few inches apart. The turrets had a thickness of 15 in. of iron, without backing. In all the vessels of the monitor type, except the side armor of last-mentioned class, the armor was made up of 1-in. plates. The turret armor of all was of this description. The use of bolts and nuts in setting up the turret plates was a grave mistake, as a very large percentage of the casualties in the monitor turrets was due to flying nuts and fragments of bolts.

By far the most successful iron-clad of the Federal war-fleet was the *New Ironsides*, one of the original three ordered by the Naval Board. She was a casemated sea-going armor clad, with the sides of the casemate inclined at an angle of 30° from the perpendicular, and protected by 4½ in. of *solid* armor-plates, with a backing of 21 in. of oak. The water-line belt was carried completely around, but otherwise the ends were without armor. The armor

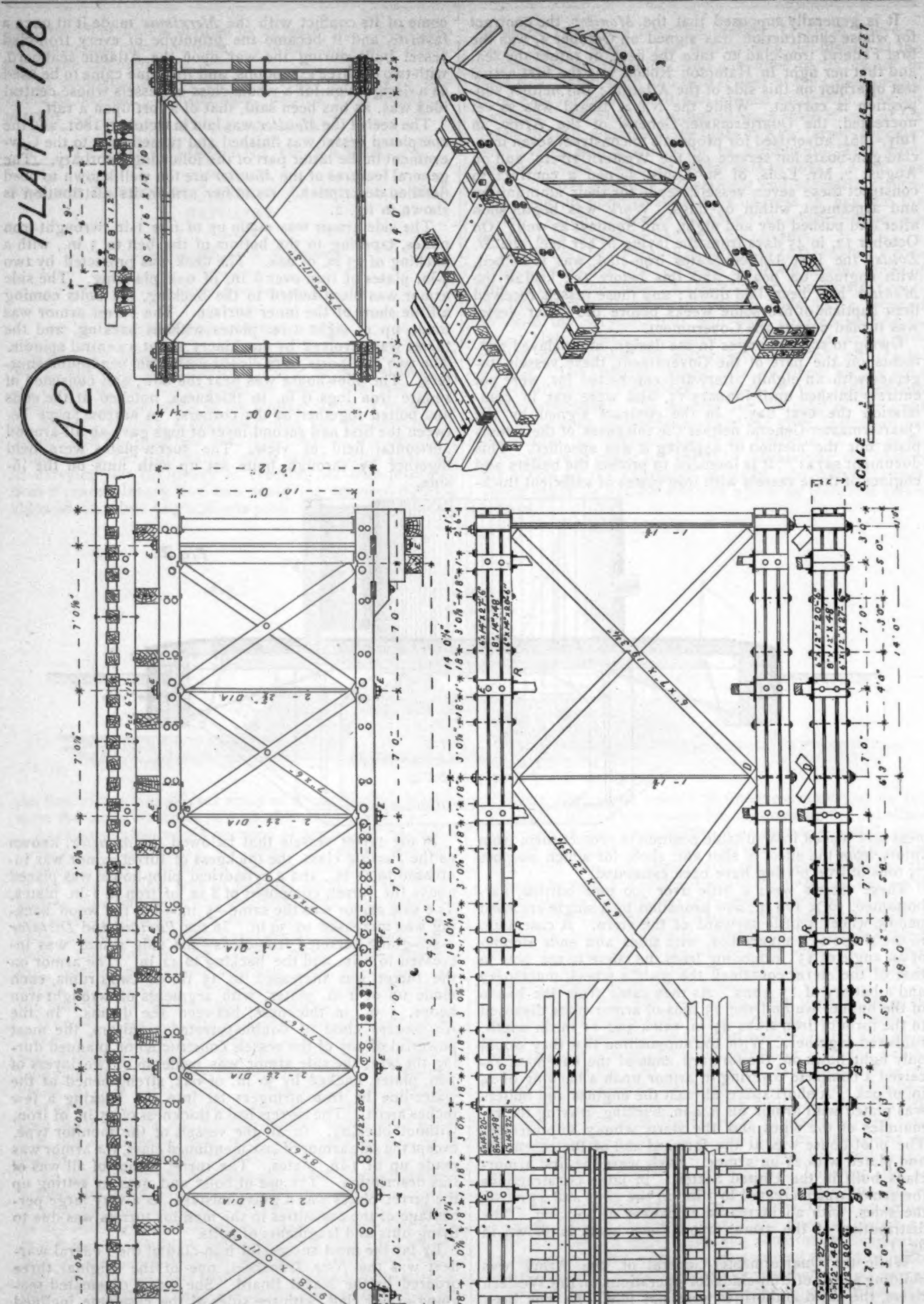


PLATE 106
42
SCALE
10 FEET

was secured to the backing by wood screws reaching two-thirds through the wood.

The superiority of the 4½-in solid armor of the *New Ironsides* over the laminated plates of the monitors was most decided. Not only this, the armor fastenings were in every way superior. The wood screws of the one held firmly where the blunt bolts of the other would be shaken loose and lose their grip; while, as a protection against the flying nuts and bolt-heads of the monitor pilot-houses and turrets, all sorts of expedients had to be resorted to.

As has been stated, the first iron-clads built in the West were constructed under the auspices of the War Department, with a naval officer in active supervision. When finished naval officers were assigned to command, and their crews were made up largely of navy enlisted men, supplemented by details from the army. The vessels themselves were, however, under the general control of the army commander. This division of authority naturally led to complications, and after about a year's trial this anomalous state of affairs was ended by a transfer of the whole matter of construction and control to the Navy Department, where it properly belonged.

Although the casemated type of armor-clads was generally adopted in the West, there were, however, a number of light-draft turret vessels constructed; three with single turrets of 6½-in. and four with double turrets of 8½-in. armor. In addition to these, there was a class of armored vessels known as "tin-clads." These were stern-wheelers, all of them, drawing not over 3 ft. of water, and covered all around to the height of 11 ft. with iron plating from ½ in. to ¾ in. in thickness, and capable of resisting musketry. The boilers were protected to resist projectiles from field guns. Armed with howitzers or light-rifled guns, these boats did gallant service among the bayous and narrow streams where other craft could not venture.

The iron-clad fleet of the United States built and begun from 1861 to 1865 consisted of 82 vessels, not including the "tin-clads." Of these, 64 were turret and 18 casemate vessels. A number of these were never completed, and some were found, when finished, to have no practical value.

(TO BE CONTINUED.)

THE USE OF WOOD IN RAILROAD STRUCTURES.

By Charles Davis Jameson, C.E.

(*Continued from page* 158.)

CHAPTER XXIV.

HOWE TRUSS DECK BRIDGES.

The accompanying plates show a design for a Howe truss deck bridge. The drawings are made in the same way as those for the bridges given in previous numbers, but on a somewhat larger scale, which will, it is believed, make them easier to read.

The design is for a bridge of 42 ft. span, Plate 106 showing the general design and Plates 107 and 108 the details and castings.

No. 44. Bill of Material for Howe Truss Deck Bridge, 42 Ft. Span. Plates 106, 107 and 108.

Wrought-Iron—Rods and Bolts.

No.	Description.	Diameter.	Length.	No.	Description.	Diameter.	Length.
8	Rods.	2¼ in.	14 ft. 6 in.	68	Int'nal bolts	⅝ in.	2 ft. 1½ in.
8	"	2⅝ in.	12 ft. 10 in.	12	Bolster-b'lts	1⅛ in.	2 ft. 4 in.
8	"	2¼ in.	12 ft. 10 in.	56	Floor-bolts.	1⅛ in.	3 ft. 0 in.
4	"	1⅝ in.	12 ft. 10 in.	28	Tr. str'r b'ts	⅝ in.	2 ft 10 in.
8	Laterals.	1⅜ in.	18 ft. 6 in.	24	Tie-bolts.	⅝ in.	2 ft. 6 in.
16	String'rb'lts	⅝ in.	2 ft. 6 in.	14	Guard-bolts.	¾ in.	1 ft. 3 in.
92	Chord-bolts.	¾ in.	2 ft. 0½ in.	24	Spikes.	½ in.	....
12	Brace-bolts.	⅝ in.	2 ft. 0½ in.				

Timber.

No. of Pieces.	Description.	Size.	Length.
4	Top Chord.........	6 in. × 14 in.	27 ft. 6 in.
4	" "	6 in. × 14 in.	20 ft. 6 in.
2	" "	8 in. × 14 in.	48 ft. 0 in.
4	Bottom Chord......	6 in. × 12 in.	20 ft. 6 in.
4	" "	6 in. × 12 in.	27 ft. 6 in.
2	" "	8 in. × 12 in.	48 ft. 0 in.
8	Main Braces........	9 in. × 8 in.	11 ft. 6⅝ in.
8	" "	8 in. × 6 in.	11 ft. 6⅝ in.
8	" "	7 in. × 6 in.	11 ft. 6⅝ in.
12	Counters....	7 in. × 6 in.	11 ft. 6⅝ in.
16	End Posts..........	8 in. × 10 in.	9 ft. 10⅛ in.
8	Laterals.......... ..	6 in. × 7 in.	19 ft. 3¼ in.
4	"	6 in. × 7 in.	22 ft. 3¾ in.
4	"	6 in. × 7 in.	19 ft. 3¾ in.
4	"	6 in. × 7 in.	13 ft. 10⅛ in.
14	Internal............	7 in. × 6 in.	17 ft. 3 in.
8	Bolsters............	6 in. × 10 in.	6 ft. 0 in.
8	"	8 in. × 10 in.	6 ft. 0 in.
8	Bridge-seat..	6 in. × 10 in.	4 ft. 0 in.
4	" "	8 in. × 10 in.	4 ft. 0 in.
4	Sills................	12 in. × 12 in.	18 ft. 0 in.
14	Floor-beams........	9 in. × 16 in.	17 ft. 10 in.
6	Stringers...........	6 in. × 12 in.	48 ft. 0 in.
44	Ties.....	8 in. × 8 in.	12 ft. 0 in.
2	Guard-rails.........	6 in. × 6 in.	48 ft. 0 in.
4	Plank..............	2 in. × 8 in.	48 ft. 0 in.
8	Blocks....	2 in. × 8 in.	2 ft. 0 in.

Castings.

Number: 8 of pattern *A*; 20 of *B*; 8 of *C*; 8 of *D*; 28 of *E*; 56 of *F*; 60 of *G*; 32 of *H2*; 16 of *J4*; 120 of *J2*; 600 of *J1*; 2 of *K*; 4 of *L*; 4 of *M*; 2 of *P*; 28 of *R*; 8 of *S*.

With the accompanying bill of material this design will require little or no further explanation; but some remarks upon it will be made in a future chapter.

(TO BE CONTINUED.)

COAL-FIELDS OF THE STATE OF WASHINGTON.

(Paper read before the Tacoma Society of Civil Engineers, by W. J. Wood, C.E).

The coal-fields of the State of Washington, or, I might say more correctly, the coal measures of the Puget Sound basin, consist of alternating beds of sandstones and shales, interstratified with many beds of carbonaceous shales and coal, showing that the period or age is of tertiary formation.

It is found that they lie in a wide trough between the Cascade and Olympic ranges, and east of the Cascade Mountains are found also extensive coal basins of older formations. The lignites of this country, however, are found in the central part of the trough lying west of the Cascade Mountains and north of Green River, and stratigraphically in the upper series, while south of the above-mentioned places and lower down in the measures will be found the true coals, or those resembling them. It is the prevailing theory that the tertiary rocks rest unconformably on the cretaceous—that is to say, that they were separated from each other by a lapse of time, during which the folding of the older coals and elevation of the mountains took place, and that probably after the development of the latter formations there was a general submergence, depositing the tertiary strata, which follows the cretaceous, and I have found in my examinations hints of the latter formations in various positions. But it is not improbable that in some places there may be a more or less complete strata of passage beds between the cretaceous and tertiary, as we find by comparison on the eastern slope of the Rocky Mountains, where I observed hints of it three years ago in Colorado, Wyoming and Montana coal-fields. I might add that it is quite possible that there may be two unconformable series of tertiary rocks. However, much

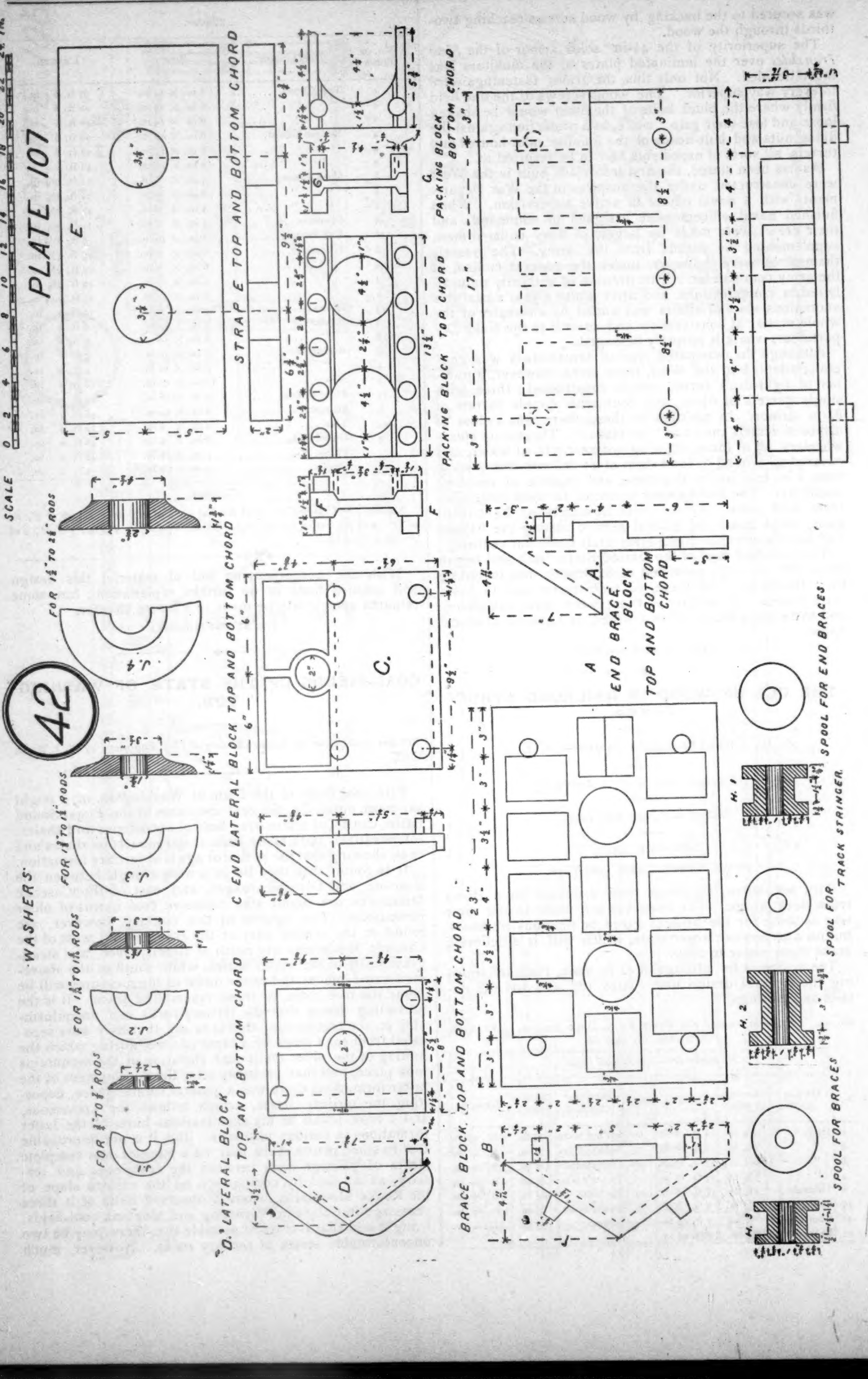


PLATE 107
SCALE
24 IN.
42
WASHERS
FOR 1 1/2 TO 2 1/2 RODS
FOR 1" TO 1 1/4" RODS
FOR 1/2" TO 1" RODS
FOR 3/4" TO 1" RODS
E
STRAP E TOP AND BOTTOM CHORD
PACKING BLOCK TOP CHORD
G. PACKING BLOCK BOTTOM CHORD
F
C END LATERAL BLOCK TOP AND BOTTOM CHORD
C.
A END BRACE BLOCK TOP AND BOTTOM CHORD
A.
D. LATERAL BLOCK TOP AND BOTTOM CHORD
D.
BRACE BLOCK, TOP AND BOTTOM CHORD
B
SPOOL FOR END BRACES
SPOOL FOR TRACK STRINGER.
SPOOL FOR BRACES
H. 1
H. 2
H. 3

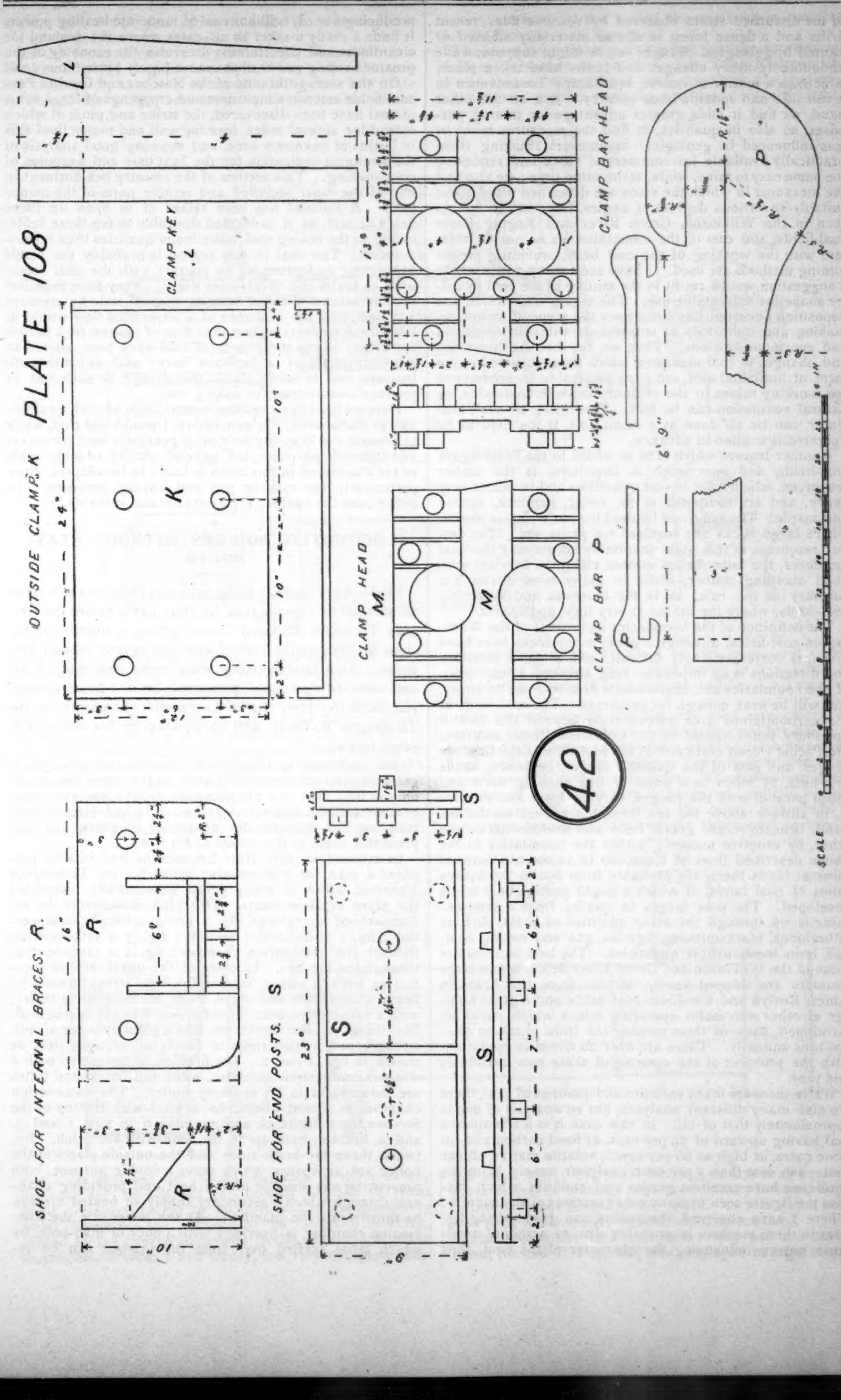


PLATE 108
OUTSIDE CLAMP K
CLAMP KEY L
CLAMP HEAD M
CLAMP BAR P
CLAMP BAR HEAD
SHOE FOR INTERNAL BRACES R
SHOE FOR END POSTS S
SCALE
42

of the disturbed strata observed by volcanic flues, recent drifts and a dense forest is not so materially affected or altered by geological changes as one might suppose, while undoubtedly many changes and faults have taken place, which, as a matter of course, is a natural consequence in a volcanic and mountainous country. But, on the other hand, we find it adds greater advantage for mining purposes, as also in qualities, to find the measures more or less influenced by geological manœuvers, making them practically available for commercial value and rendering the same easy to mine, while, at the same time; we also find the measures in which the veins are described tilted about suitably in various degrees of angles, from 20° to 85°, as seen in the Wilkinson, Green River and Raging River coal-fields, and east of the mountains, so as not to interfere with the working of the coal beds, providing proper mining methods are used. I have seen many mines where a suggestion would result in the mining of the coal in better shape for marketable use. The region over which this deposition occurred has since been the scene of mountain-making and upheavals of stupendous volcanic eruptions and enormous erosions. Thus we see that the diversities and changes in coal measures which have occurred in the form of anticlinal axis, etc., are preferable in schemes of the working mines to the ordinary flat-vein coal-fields, as natural ventilation can be had. The lifting of coal, also water, can be all done at a small cost, if the field to be operated is studied in advance.

Another feature which is to be added to the Washington coal-fields, and one which is important, is the timber resources, which exist in vast quantities and in places very heavy, and are composed of fir, cedar, hemlock, spruce and maple. The same can be used for timbering in mines, where large sticks are required for props, etc. The timber resources in this State invariably accompany the coal measures, the latter being without exception overlaid with good standing timber, while in many other States the contrary is the rule, as in the Montana and Wyoming coal-fields, where the timber is very light and sparse.

The definition of the boundaries and extent of the Washington coal-fields, although a great many areas have been given, is correspondingly difficult, and in some locations and directions is an impossible task, although a description of the boundaries and approximate area will not be amiss, and will be near enough for exactness. The coal-fields or the carboniferous area extend from beyond the British boundary south almost to the Columbia River, and from the Pacific Ocean eastward to the foot-hills of the Cascade ranges, and east of the Cascade ranges, beginning at the foot-hills, 25 miles to a point or line running north and south parallel with the ranges, varying from 800 to 5,000 ft. in altitude above the sea level, but buried, on the one hand, beneath recent gravel beds and overflowed, on the other, by eruptive masses; within the boundaries of the above described lines of 8,000,000 to 10,000,000 acres of mineral lands there are probably from 600 to 700 square miles of coal lands, of which a slight portion only is yet developed. The coal ranges in quality from a semi-anthracite up through the other qualities of coals, such as bituminous, blacksmithing, lignites, gas and coking coal, and is in inexhaustible quantities. The best sections are those of the Wilkinson and Green River fields, where large amounts are shipped yearly, as also from the Franklin mines, Roslyn and Cle-Elum coal-fields and a great number of other successful operating mines which could be mentioned, some of them turning out from 50,000 to 200,000 tons annually. There are over 20 mines in operation, with the prospect of the opening of three new coal-fields this year.

While there are many varieties and qualities of coal, there are also many different analyses, but an analysis of one is approximately that of all. In this case it is a bituminous coal having upward of 59 per cent. of fixed carbon and, in some cases, as high as 66 per cent.; volatile matter, 28 per cent.; ash, less than 5 per cent.; sulphur, none. With the lignite we have excellent grades and qualities, which surpass the lignite seen in many other sections of the country. Where I have observed, the quality and grade of the lignites in these sections is probably due to action of a volcanic nature influencing the character of the coal, thus producing a hard, brilliant coal of moderate heating power. It finds a ready market in all cases where the demand for cleanliness and cheerfulness overrules the economy of the greater heating power of the more highly bituminous coal.

On the semi-anthracite of the Natchez and Cowlitz Pass coal-fields extensive measures and croppings of large veins of coal have been discovered, the strike and pitch of which extend for several miles, forming anti and monoclinal axis in basins of unknown area, and showing good analysis of the strongest indication for the best uses and purposes of coke-making. This section of the country lies dormant in one of the most secluded and remote parts of the mountains. A railroad has been talked of to open up these fields of coal, as it is deemed desirable to tap these fields, owing to the coking and bituminous qualities thus recommended. The coal in this region is probably the result of volcanic rocks running in contact with the coal measures, as faults and as intrusive dikes. They have modified the character of the coal from its original state by pressure and heat, and the influence of a superficial flow would in both these respects be less than that of molten rock before extrusion. Thus these beds of coal have been altered to semi-anthracite of a brilliant luster and an anthracite fracture, and in some places the change is sufficient to produce a bituminous or coking coal.

Here we have reviewed the several kinds of coal, qualities and probable area. In conclusion, I would add that, while at present the Washington coal is generally used for steam and domestic purposes, the general quality of other coals so far discovered in this State is found to be adapted more particularly for making gas and coking purposes. In either case the coal is very desirable and valuable.

LOCOMOTIVE BOILERS WITHOUT STAY-BOLTS.

IN the April number of the JOURNAL there was published an abstract of a paper read by Herr Lentz before the German Technical Railroad Union, giving a number of designs for locomotive boilers with corrugated tubular fire-boxes. At a later meeting some comments were made and some further plans presented for fire-boxes without stay-bolts, by Herr Bork, Locomotive Inspector of the Thuringian Railroad, and an abstract of his remarks is given below:

The endeavor to simplify the locomotive boiler is of great importance, especially when at the same time economy in first cost and maintenance can be secured, with greater security against explosion. He had himself been studying this question for a number of years, and now presented some of the results of his work.

In connection with Herr Lochner he had in 1880 prepared a plan for a locomotive boiler for the Thuringian Railroad, which in many points substantially resembled the plans of Herr Lentz. This plan is shown in the accompanying engravings, fig. 1 being a longitudinal section; fig. 2 a horizontal section; fig. 3 a cross-section through the combustion chamber; fig. 4 a cross-section through the fire-box. In place of the usual form of locomotive boiler, with a copper fire-box strengthened by heavy crown-bars and stays, there is a cylindrical boiler, with a tubular fire-box. This fire-box was not corrugated, like those of Herr Lentz, but was a plain cylinder of iron strengthened by two rings or bands of wrought iron, as shown in figs. 1 and 2. The fire-box is connected with a circular combustion chamber, while the barrel and tubes are the same as in an ordinary boiler. The combustion chamber is closed above, on a level with the top of the fire-box, by a fire-brick arch, as shown in figs. 1 and 3, and is, besides, built up at the side with fire-brick. Between these fire-brick sides and the outside plates of the boiler are air-spaces which serve a double purpose, both preventing any possible loss of heat and providing channels through which a secondary supply of heated air can be thrown into the chamber. At the lower side the combustion chamber is provided with a door or man-hole, by which ashes carried over from the fire-box can be re-

moved, and which also serves to make the tubes accessible for inspection and repairs.

In the forward part of the tubular fire-box there is a fire-brick bridge held in place by two iron stay-rods passing through it, as shown in section in fig. 1. The grate is back of this bridge, and is nearly in the center of the

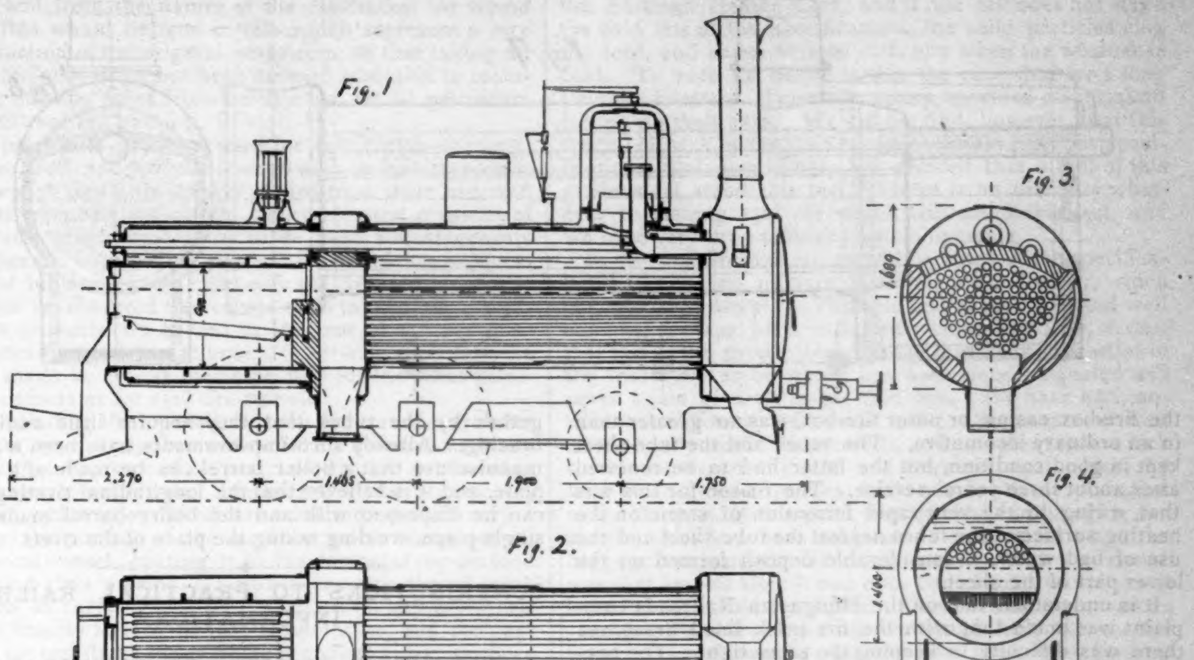


Fig. 1

Fig. 2.

Fig. 3.

Fig. 4.

tube, leaving the lower half as a space for ashes. The rear end of the tubular fire-box is closed by an iron plate, strengthened by angle-irons, and having two openings, one above for the fire-door, which is of the ordinary pattern, and one below for the passage of the ashes. Finally, there is an ash-pan or box attached to the rear end of the boiler underneath the foot-plate; this ash-pan is provided with two doors, the upper one being used for the removal of the ashes and the lower one for the admission of air to the fire-box as required.

The advantages claimed for this plan of boiler are the absence of the heavy and expensive system of braces and

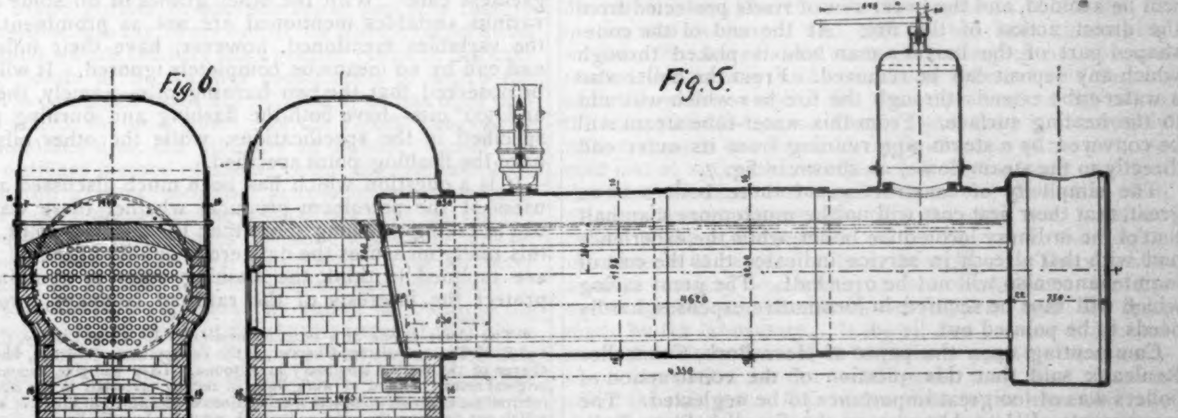


Fig. 6.

Fig. 5

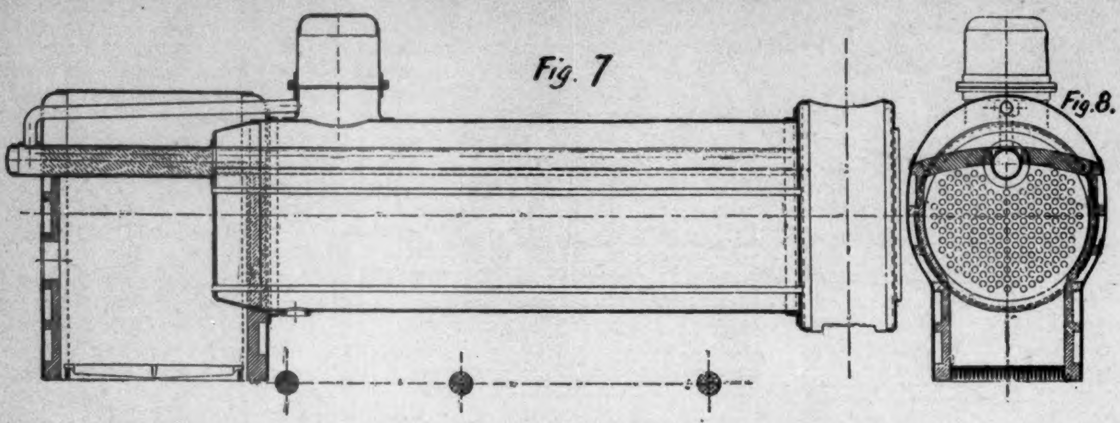
stay-bolts required for the flat surfaces of the ordinary fire-box; the capacity of the tubular fire-box to resist great pressures, owing to its form and its comparatively small diameter; the absence of the liability to crack, caused by the uneven expansion in the flat surfaces of the rectangular fire-box; and finally, the very complete combustion attained by the use of the combustion chamber and the secondary air supply.

These considerations, with the fact that the experiments of Herr Verderber on the Hungarian State Railroad had proved that a fire-box lined with fire-brick can be used without reducing the steaming qualities of a boiler, led to the rebuilding of the boiler of an old locomotive on the Thuringian Railroad on the plan shown in figs. 5 and 6; fig. 5 being a longitudinal section and fig. 6 a cross-section.

The original outside fire-box was used as a casing for the new fire-box, which was built up of good fire-brick, so arranged as to leave an air-space or channel between the brick and the outside casing. The fire-door and grate were arranged in their old places. The boiler barrel was lengthened a little, so that it projected into the fire-box about 4½ in. The rear end of the barrel was closed by the copper tube-plate, in which the tubes were secured in the usual way. The total heating surface was nearly as great as that of a boiler with the ordinary fire-box, owing to the increased length of the tubes. In this way a boiler was built without the stay-bolts usually required.

The locomotive with this boiler was put into service about the end of 1879, and was employed in regular work

until 1886. The experience gained during these years showed that the apprehension felt that the shocks experienced on the road in service might affect the durability of the boiler were unfounded. By the use of good materials in the first place long life was secured for the fire-box. The boiler steamed well, and the radiation of heat from the fire-box casing, or outer fire-box, was not greater than in an ordinary locomotive. The tubes and the tube-sheet kept in good condition, but the latter had to be renewed after about three years' service. The reason for this was that, owing to the very rapid formation of steam on the heating surface of the tubes nearest the tube-sheet and the use of bad water, a considerable deposit formed on the lower part of the sheet.



It is understood that on the Hungarian Railroads complaint was made that with the fire-brick lined fire-boxes there was difficulty in keeping the tubes tight. The reason for this was probably that the tube-sheet was carried back too far, bringing it too near the fire-door. On the Thuringian Railroad where, as stated, the boiler barrel projected into the fire-box only 4¾ in., there was no more trouble in keeping the tubes tight than in an ordinary fire-box.

The overheating and consequent injury to the lower part of the tube-sheet can be prevented, and for this purpose a boiler has been designed for a locomotive of the standard pattern in use for freight service on the Thuringian Railroad, which has six coupled wheels. This boiler is shown in figs. 7 and 8; fig. 7 being a longitudinal section and fig. 8 a cross-section.

Of this boiler it need only be said that the rear end of the boiler barrel, projecting slightly into the fire-box, is cone-shaped. In this way it is believed that the deposit of incrustation against the lower part of the tube-sheet will be avoided, and the lower row of rivets protected from the direct action of the fire. At the end of the cone-shaped part of the barrel a man-hole is placed through which any deposit can be removed. From the boiler also a water-tube extends through the fire-box which will add to the heating surface. From this water-tube steam will be conveyed by a steam-pipe running from its outer end directly to the steam-dome, as shown in fig. 7.

The simplicity of construction of these boilers is so great, that their first cost will not be much more than half that of the ordinary locomotive boiler, while the experience had with that already in service indicates that the cost of maintenance also will not be over half. The great saving which will thus be secured in locomotive expenses hardly needs to be pointed out.

Commenting upon the paper of Herr Bork, Counsellor Reuleaux said that this question of the construction of boilers was of too great importance to be neglected. The experiments of Herr Almgren on the Swedish State Railroads indicated that the usual calculations of heating surface and steaming capacity were based on an error. With proper construction the heating surface could be considerably reduced without affecting injuriously the steaming qualities of the boiler. In consequence of these experiments a system has been adopted in Sweden in which the sides of the fire-box are built up with fire-brick, provided with air-spaces or channels, as in Herr Bork's boiler; the passage of air through these is regulated by a simple arrangement of dampers.

With this arrangement the boiler is a simple cylinder, to which the fire-brick lined fire-box is attached at one end and the smoke-box at the other. The only flat surfaces are the tube-sheets, which are practically so bound together by the tubes that they require little additional bracing. Already such improvements have been made in manufacture that a boiler barrel can be made of a single plate, and it is believed that the longitudinal riveting even can be dispensed with and the boiler barrel made of a single piece, welding taking the place of the rivets.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.*

CHEMISTRY APPLIED TO RAILROADS.

VI. PETROLEUM PRODUCTS (*Continued*).

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

(*Continued from page* 181.)

It will be observed in reading the specifications that the fire test as a means of determining the quality of petroleum products, which was discussed to quite an extent in the last article, especially as applying to 150° oil, applies also to all the other grades of petroleum products generally used by railroads. The 150° oil is the most sensitive, and requires that the manipulation and attention to the various variables mentioned in the last article should receive the greatest care. With the other grades of oil some of the various variables mentioned are not as prominent. All the variables mentioned, however, have their influence, and can by no means be completely ignored. It will also be observed that the two burning oils—namely, the 150° and 300° oils—have both the flashing and burning points specified in the specifications, while the other oils only have the flashing point specified.

It is a question which has been much discussed among users of the petroleum products whether there was any use in taking anything more than the flashing point, since this really measures the dangerous quality of the oil. We are inclined to think the flashing point is abundant to protect the interests of the railroad company, provided

* The above is one of a series of articles by Dr. C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad, who are in charge of the testing laboratory at Altoona. They will give summaries of original researches and of work done in testing materials in the laboratory referred to, and very complete specifications of the different kinds of material which are used on the road and which must be bought by the Company. These specifications have been prepared as the result of careful investigations, and will be given in full, with the reasons which have led to their adoption.

The articles will contain information which cannot be found elsewhere. No. I, in the Journal for December, is on the Work of the Chemist on a Railroad; No. II, in the January number, is on Tallow, describing its impurities and adulterations, and their injurious effects on the machinery to which it is applied; No. III, in the February number, and No. IV, in the March number, are on Lard Oil; No V, in the April number, on Petroleum Products. These chapters will be followed by others on different kinds of railroad supplies. Managers, superintendents, purchasing agents and others will find these Contributions to Practical Railroad Information of special value in indicating the true character of the materials they must use and buy.

the taking of the flashing point is surrounded with sufficient precautions; but as a means of additional security, and especially as a means of neglecting no precaution that could fairly be made use of to prevent accidents with the burning oils, we still adhere to the burning point as an essential feature. Moreover we have found a few oils the flashing and burning points of which were very close together, and from the nature of the distillation we would expect this would be true of oils which represent a very small fraction of the original petroleum, so that taking all things into account, it has been deemed advisable to maintain the burning point likewise as a test for all petroleum products used for burning.

The petroleum products used for lubrication—namely, paraffine, well, and 500° oils—are so high in flashing points, that there is very little danger of fire from their use, and the flashing point sufficiently determines the presence of ingredients which are too low to be used advantageously as lubricants. Accordingly for all the petroleum products used for lubrication we take only the flashing point. It will also be observed that except the 150° oil, all the petroleum products are heated at the rate of 15° per minute, instead of 12° per minute. Otherwise than this the test is made in exactly the same way for the other petroleum products as for 150° fire-test oil.

In concluding the discussion of the fire test of petroleum products, we will say that we are hardly satisfied with any method that we know of in practical use for determining the fire test of petroleum. Methods have been proposed, however, which to our minds are much more satisfactory—notably, the putting of the oil in a rather deep, small, cylindrical vessel, heating it to the temperature decided upon, and then passing air slowly through the oil, with the idea of carrying out of the heated oil any vapor that may be readily formed at that temperature, and then applying the test flame to see whether enough vapor has been carried out to cause a flash or slight explosion. The oil would pass test if no flash occurred; would not pass test if a flash occurred. We are planning some experiments on this method of testing, and are inclined to feel from our present knowledge of the case that this method will give results which will be more satisfactory and give greater certainty as to the quality of the oil used than any method we now know of in practical use. The limitations and details of the method we have not yet fully worked out, and are therefore unable to give anything more positive in regard to it at present.

Returning to the specifications, it will be observed that all the oils except the 500° oil have a cold test specified. The question of cold test has been discussed somewhat in the previous article on Lard Oil. In addition to what is stated there we will add that the difficulty of the separation of the various constituents when under the influence of cold is much greater in the petroleum products than in lard oil—that is to say, every one of the petroleum products with which we are familiar has a greater range in the congealing points of the various constituents of which the product is composed than lard oil, and if, as has been previously stated, the one which has the highest congealing point solidifies first, the difficulty of making a cold test by the ordinary method of seeing when the test sample is solid is still greater with the petroleum products than with lard oil. We accordingly make our cold tests of the petroleum products in exactly the same way as for lard oil—namely, freeze the sample if possible with a thermometer suspended in the oil, and then determine the point at which the mass will run from one end of the bottle to the other, calling the reading of the thermometer at that point the cold test of the oil. The two petroleum products which are used for burning do not, however, admit of this method of testing, since the 150° oil especially is so low in congealing point that it is very difficult to freeze the mass. We accordingly for this purpose expose the oil to the temperature mentioned in the specifications, and see if it shows any cloudy appearance, due to the congelation of any of the paraffine wax, or any material in the oil which is solid at that point. With 150° oil we use a mixture of ice and salt, which gives a temperature approximately zero, and as stated in the specifications, the oil must remain clear for ten minutes at the temperature of this freezing mixture. Many of the 150° fire-test oils of the market will stand this test without any difficulty whatever, some of them standing as low as 20° below zero, before they show a cloudiness. On the other hand, many of the 150° oils of the market become cloudy or opaque, even 10° or 15° above zero. The necessity for this specification for 150° oil is due to the fact that this grade of oil is used on the Eastman Heater Cars, and if the oil does not stand the cold test of the specifications, the solid particles clog the feed, and cause serious difficulty when the weather is cold. To such an extent is this the case that for a long time the Eastman Heater Company specified a special oil for use on their cars. We did not find, however, that this special oil was better than oil which would pass our specifications, and accordingly we decided that all oil of this grade must stand this test. There is no difficulty whatever in making 150° oil which will stand this test, and we have very little difficulty with shipments.

In the 300° fire-test oil, as will be noted in the specifications, the cooling mixture is simply ice and water, which is exceedingly simple. The cold test of paraffine and well oils has, perhaps, been sufficiently commented on, except that this is the proper place to say that there is a belief in the trade that an oil which has been once congealed will never again give the same cold test. We have had considerable difficulty due to this belief. Shipments of well oil especially would be received, and samples taken which would not stand the cold test required, and which, by tests made by other parties, it did stand. The explanation of the shippers on this point was that the can bringing the sample to us had been subjected to cold in transit in the baggage car, and the oil frozen, and that their experience was that any oil after it had once been frozen would never have the same cold test again. This peculiarity caused us considerable difficulty until we found how the matter stood. The explanation given by the shippers according to our experience is not correct. An oil can be frozen and thawed as often as one chooses without affecting its cold test at all, and we have obtained exactly the same cold test from the same kind of oil after freezing and thawing it a good many times. The explanation of the difficulty is as follows: If a can carrying an oil sample is exposed to the cold in transit, especially if the cold is rather slowly applied, part of the oil near the outside of the can congeals, crowding the more limpid portions, as has already been explained, to the center of the can. The cold might be sufficient to congeal all the oil in the can. When it is brought into the laboratory, the can is usually allowed to stand a little while until attention can be given it. Of course during this time it was thawing out and thawing slowly. When now the oil is taken in hand for test, it may or may not be wholly thawed out, and that portion of the oil which is poured out for test under these conditions will not therefore be the same as if all the oil in the can is limpid and the oil has been thoroughly mixed. We have taken successive samples out of a can treated in this way, and obtained a different cold test on each successive sample. On the other hand, if the oil in the can has all become limpid, and then is thoroughly mixed, so as to become uniform in all parts of the can, the cold test of successive samples will be the same, and furthermore the same can may be frozen and thawed as often as one chooses without affecting the cold test, provided before making the test the oil in the can is thoroughly mixed so as to become uniform throughout. There is also another cause of discrepancy in cold test between the tests made by the manufacturers or shippers and the tests made by the laboratory. If the oil has become congealed in the barrels in transit, it is entirely possible that sufficient separation of the constituents may take place to affect the cold test. Our instructions to the men who take the samples are to roll the barrels about in the winter season before the sample is taken for test. We usually have very little difficulty from this cause, since our specifications require zero oil in the winter, and also since the material is usually not very long in transit. In colder climates it is entirely possible that the difficulty of the oil congealing in the barrels might become a very serious one, in which case it would be necessary in all cases to have the oil thoroughly thawed out and the barrels rolled

around, and possibly the heads of the barrels taken out and the oil stirred, in order to get a fair sample for test.

The specific gravity of petroleum products is a very common test in the trade, and this, together with the fire test, are the usual means of determining the quality of the oil which the trade employs. It will be observed in our specifications that we have paid no attention to the gravity in the two oils used for burning, nor in the 500° fire-test oil, used, as will be explained later, for cylinder lubrication. The paraffine oil and the well oil have tests for gravity. It is claimed by some well-known refiners of petroleum that the test for gravity also should be applied as a means of determining the quality of burning oils. The test for gravity has something of the same effect, however, as fire test—that is to say, those constituents of the petroleum products which are lowest in fire test are also lowest in gravity, and in our experience we have not found it necessary to specify gravity for the burning oils. There is another phase to this question, however. The facility with which the oil flows up the wick unquestionably bears some relation to its value as a burning oil, and we believe some of the refiners claim that there is a relation between the gravity and the capacity of the oil to flow up the wick. The tests which we apply, however, are those which our experience has indicated as essential to give us the product that we want, and as no necessity has ever arisen in our experience indicating that it was essential to take the gravity of the burning oils, nor to devise tests for the rate of flow up the wick, we have allowed these two subjects to rest until some necessity should arise, holding ourselves quite at liberty to add further tests to those now in force, if occasion demands. In lubricating oils there is believed to be a relation between the gravity and the value as lubricants. Our experiments indicate that with the same kind of oil, the heavier the gravity the more viscous the oil, and consequently it will give somewhat higher friction. On the other hand, the lighter the gravity the less viscous the oil and the less friction. Extremes in either direction are dangerous—that is to say, if the oil is too viscous, much power is lost in overcoming this viscosity; if the oil is too limpid, the surfaces are not held far enough apart to prevent rapid wear and danger of heating. Accordingly an attempt has been made in our specifications to reach a mean between these two extremes, so far as this mean is measured by the gravity. With oils of different kinds, however, we have never succeeded in discovering any relation between the gravity and the lubricating power. For example, a lard oil of the same gravity as petroleum does not give the same results on test; or again sperm oil does not give the same results as paraffine oil of the same gravity, and in truth all our experiments have failed to show, when oils of different natures are mixed together, or are tested alone, that there is any relation between the gravity and the lubrication. With oils of the same kind, however, there is some relation between the gravity and the lubricating power. There is very little difficulty in getting in the market paraffine and well oils which come within the limits of our specifications, and a long experience has indicated that so far as gravity goes oils meeting our requirements give very good results.

In regard to the remaining tests for petroleum products, the two burning oils are required to be "water-white" in color, and there are not a few among the refiners who think that a yellow oil gives equally good results in burning as "water-white" oil, and we are hardly prepared to dispute the position. The reason for demanding "water-white" oil is that by the ordinary method of distillation, the oils contain some tarry matter, unless this is removed, as has been previously described, by treatment with oil of vitriol; and as the demands made on our burning oils are rather severe, we have felt that we were entitled to all precautions possible to prevent clogging of the wicks, the tar, as is well known, remaining in the wicks and causing them to crust. We accordingly demand "water-white" oil. Many times the market falls a little short of "water-white" oil, and what is known as "prime white" is frequently sent in place of "water white." The distinction is not very sharp, and we are ofttimes compelled to accept material that is somewhat less than "water white."

The question of cloudy oil is a very serious one. The most common cause of cloudy oil is due to the following points in manipulation at the refineries where the oil is barrelled. The barrels, in order to make them tight, are treated on the inside with a dilute solution of glue. It sometimes happens that owing to carelessness either the gluey solution is not wholly drained out or the barrel is not allowed to become sufficiently dry before the oil is put in. In this case the gluey matter, owing to the shocks of rolling and shaking incident to loading on cars and transportation, becomes thoroughly mixed up with the oil, giving it an opaque or cloudy appearance, which cloudy appearance is very slow to disappear by settling. These little particles of glue or glue and water finely divided, suspended in the oil, are when the oil is used for burning soaked up into the wick, and clog it, as will be readily understood. We have had much difficulty from this cause, and the rule is enforced quite strenuously that cloudy oil will not be received. The sample sent for test being, as the specifications state, a sample from a single barrel chosen at random, and the bad condition of a barrel when it is full being characteristic of any barrel in the shipment, it does not always happen that the sample which we receive shows a cloudy appearance, although other barrels in the shipment may do so. To obviate this difficulty, the instructions to the men at the oil houses are that all barrels containing cloudy oil must be returned to the shippers, they themselves performing the inspection necessary to determine this point. Long standing in a quiet position will cause most of this material to precipitate, but the supply carried at most of the oil houses demands that the oil be used moderately quickly after it is received, and consequently we have preferred to return cloudy oil rather than attempt to use it.

The viscosity test applied to the paraffine and well oils has something of a history. For a number of years the Pennsylvania Railroad Company has made tests on the Thurston oil-testing machine of the well oil samples especially, this being, perhaps, the most important oil used for lubrication. It was the custom to ask the manufacturers to furnish a sample of such oil as they were willing to furnish for the ensuing month's supply. These samples were tested in the laboratory, as to whether they would fill the specifications given in the printed sheet. They were also tested on the oil-testing machine. The information from both these sources was sent to the purchasing department, and in placing orders, first all samples which did not fill the requirements of the printed specifications were thrown out. Those that were left were examined in the light of the lubricating test, and orders placed on those samples only which came within certain limits of friction. Neither too low nor too high friction was desired. This test was used for quite a length of time, but the manufacturers complained that they had no means of duplicating these tests, since duplicate results from different machines are very hard to get, and therefore they were somewhat in the dark as to how to meet the requirements of our lubricating test. If they sent a sample of oil, it might fill the lubricating test and it might not, and they had no information to enable them to modify the oil so that it would meet the requirements. In view of this state of affairs, which was regarded by ourselves as a just criticism, the viscosity test was devised. It is of course assumed in this test that the viscosity of the oil is an important element in the friction which results when the oil is used in service, and it becomes quite an interesting question as to whether the viscosity test would give results corresponding to the results obtained in actual service. We hope to prepare some articles on lubrication, and this question will then be discussed *in extenso*. Meanwhile it is, perhaps, sufficient to say that for a number of months the viscosity test has been supplemented on the same sample by a test on the oil-testing machine, and while there is no absolute agreement between the results of the two in case of every oil, yet the discrepancies are so narrow that no oil which would be rejected on lubricating test would be accepted on viscosity test, and *vice versa*. In other words, the two tests run very closely together. We are quite well aware that elaborate viscosimeters have been prepared so delicate that even the presence of a small amount of lighter oil added to the oil under test will show. These viscosimeters are unquestionably of great value,

but for a practical test which could be applied by the manufacturers themselves, and which would at the same time give indications sufficiently accurate for the general use of railroads, we think the viscosity test as we employ it is sufficient. In developing this test we found one or two points which were very interesting. Of course it was essential that the pipettes used should be capable of duplication, and any one who has tried to get pieces of glass apparatus which were exact duplicates of each other knows that this is almost impossible. However, after making a large number of experiments, we found that the size of the bulb of the pipette and its length, and the size and length of the tube above the bulb, have very little influence on the test. On the other hand, the length and size of the tube below the bulb, as well as the size of the aperture, are of very great importance. It was almost impossible to get pipettes that would give the same results, as they are ordinarily graduated. On the other hand, if the pipettes were regraduated so as to hold just 100 cubic centimeters to the bottom of the bulb, the difficulty due to the length and size of the tube below the bulb disappeared. We now buy our pipettes regraduated by the makers, and the lower aperture adjusted as above described, and have no difficulty in getting duplicate tests on the same oil with different pipettes. We use a stop watch, which gives us results to within a second. It will be readily understood how the temperature of the oil and the temperature of the room have an influence on the test; the higher the temperature the greater is the limpidity, and the more rapidly the oil will run from the pipette. We always stir the sample after it is heated to the required temperature, so as to be sure that it is uniform throughout.

The statement in the specifications that paraffine oil must be pale lemon color is more a concession to the paraffine oil refiners than an essential prerequisite. Oils are offered in the market in competition with paraffine oil which are redder than paraffine, and the refiners think it unjust that these oils should be allowed to go in under the same specifications as paraffine oil, since they are more cheaply made, and do not have quite the same qualities as genuine paraffine oil. Accordingly the color was made an essential part of the specifications. Smith's Ferry oil is really a species of well oil, except that it is not dark in color. It has also a slightly lighter gravity, but otherwise has much the same physical properties as the well oil. We have obtained very good results with this oil in place of paraffine oil during the summer season, but as it is impossible to make Smith's Ferry oil which will stand the cold test required in the winter, we do not attempt to use it during the cold weather.

The flashing point of well oil is varied, as will be observed, according to the time of the year. This we have found to be essential, since in the winter season it is impossible or extremely difficult to get a cold test such as is essential for use at this season of the year with a flashing point that is required during the remainder of the year. We have seen many samples of oil which would stand our cold test that did not flash below 249° Fahrenheit, but this is not generally the case, and accordingly we drop off a little in flashing point, to enable some of the lighter constituents of the petroleum to appear in the well oil, thus accomplishing two purposes: First, securing a better cold test, since the lighter portion of the petroleum stands cold test better than the heavier portion, and also second, since the lubrication in the winter is done at a lower temperature, we can use more limpid oil than we can in the summer. The viscosity of the oil in the winter and in the summer is quite different, and the effect of this on train resistance is very marked. A sudden cold snap with summer oil in the boxes diminishes the number of cars in a coal train sometimes by as many as three or four. This point in regard to the effect of the viscosity of the oil on train resistance will be discussed still further when we come to some articles on lubrication.

The precipitation test for the well oil and the 500° fire-test oil is for the purpose of excluding tarry and suspended matter. From the method of distillation used in refining petroleum products, it often happens, especially if high heats are used, that a very heavy viscous substance occurs in the oil sent out by the refiners as lubricant. Moreover, it seems probable that what are known as "still bottoms," which are the very heavy parts of the petroleum left in the still when making certain kinds of oil, are mixed with the lubricating oils by certain refiners. We have seen oils which were simply nothing but mixtures of slightly reduced crude with "still bottoms." These still bottoms and, indeed, the tarry matter itself are objectionable as lubricants, and we have accordingly for a long time tried to get some means of rejecting oils which contained these in large amounts. The old test used for this purpose was to pour a little of the oil on a piece of glass and allow it to run down in a stream off the edge. On holding the glass up to the light, if black specks or clots of blackish-brown appeared, the oil was regarded as inferior, and was rejected. This test worked very well for a while and completely excluded the still bottoms, but after a while the manufacturers learned to mix enough of the inferior material with the oil to give a pretty dark brown, and as there is no means of distinguishing between different shades of color, we found we were receiving inferior oil under this test—that is to say, our specifications rejected oil that was darker than reddish brown; but as reddish is not a definite color, we found our shipments were constantly becoming more and more of a blackish brown, without our being able to draw a distinction sufficiently sharp to enable us to reject shipments without dispute. Still further we have once or twice found an oil which was all right in color, but which was apparently a mixture of heavy residues from some part of the distillation and lighter oils, and which was a very poor lubricant. Accordingly the precipitation test was devised. This test is based on the fact that the heavier members of the paraffine series are insoluble in the lighter members. The tarry matter and the "still bottoms," and any other inferior material in a sample of oil falls to the bottom of the vessel when the oil is mixed with gasoline, as described in the specifications. This test works charmingly and secures an excellent oil in the grades to which it is applied.

The grade of oil known as 500° oil in our specifications is what was formerly known in the market as 600° oil. It is also known under the name of cylinder stock. The flashing point and the precipitation test are all the tests which we have found it essential to apply to give us in this grade of oil all that is required.

It will be observed that the Pennsylvania Railroad specifications do not provide for the use of any of the filtered petroleum products. We have many times been asked to use filtered oils, on the ground that they were better. Our tests seem to indicate that while the oils present a better appearance, they do not in service give enough better results to pay for the increased cost, and accordingly we do not attempt to use any of the filtered oils.

In addition to the oils previously described in this series of articles, specifications have been prepared for tallow oil and neatsfoot oil. Neither of these oils, however, have been able to compete in price with the two grades of lard oils, and we have accordingly used very little of them during the last fifteen years. If at any time the relative cost of these oils or, indeed, of colza oil, peanut oil or rapeseed oil should enable these oils to compete or be used with economy, specifications would be prepared for those for which we have no specifications as yet, and the specifications already prepared for tallow oil and neatsfoot oil would come into prominence.

It will be noticed in the specifications for the various kinds of oils that a single sample of about a pint, taken from any barrel at random, is sent for test, and that this represents the shipment, and that the shipment stands or falls on this single sample. Some of the manufacturers and dealers have thought our method of sampling was hardly fair, that in reality the sample ought to be a composite one, a little being taken from each barrel. This question has been much discussed, and the reasons that have led us to the practice which we have—namely, of taking a sample from a single barrel selected at random—are, first, it is no small job to sample a lot of 50 or 100 barrels of oil, and our force at the oil house would hardly warrant us in going into such extensive sampling; and second, the oil in the shipment ought all to be of the quality ordered, and if it is all of the quality ordered, and

is uniform, a sample from a single barrel is as good as a sample from all the barrels. There is a phase of this question, however, which will bear a word further. We have had shipments in which all the oil except two or three barrels was of uniform grade and quality, apparently all except the two or three barrels having been barrelled from the same tank. This sending of a small amount of inferior oil happens in this way. An order calls for a little more oil than happens to be in the tank at the shipper's works, and to fill out the order two or three barrels are taken from another tank, which in some cases have been inferior oil. It is fair to say that in this case there is a chance for injustice to ourselves, for if by chance the sample which we get for examination comes from one of the good barrels, the whole lot is accepted, and we actually get some inferior oil in place of the good oil that was bought. On the other hand, if our sample comes from one of the inferior barrels, the whole shipment is rejected, and the shipper has to pay the return freight. Our position in this matter has been that if the shippers were willing to take the risk of our getting a sample from an inferior barrel, we were willing to take the risk of our getting a sample from a good barrel. Fortunately for ourselves, in two or three cases which we know about from subsequent investigation, we have happened to get our sample from an inferior barrel. In one case which we specially have in mind, the manufacturer had an order for 45 barrels of lard oil of the best grade. The foreman at the factory had only 42 barrels of that kind of oil in stock, and being anxious to make the shipment, filled out the order with three barrels of inferior oil. Our sample came from one of these three barrels, and the whole shipment was rejected. The parties made some stir over the matter, but we simply told them we were very glad the matter had turned out as it did. They of course did not attempt to uphold the foreman, but thought that a fair method of sampling would have caused us to accept 42 barrels and only returned the three. Our system of a single sample representing a shipment has worked so well that we should be very loath to abandon it. It is in reality something of a check on our receiving inferior material, due to the fact that the manufacturers know that the whole shipment goes back if perchance the sample which we have for test is inferior material. It is only fair to say that the return freight on most shipments of material costs actually more than the profit would be.

In the next article of this series we will describe at length how the oils which have been treated in the six articles of this series on oils are used, giving the mixtures and the results of our experience with these mixtures.

(TO BE CONTINUED.)

THE ESSENTIALS OF MECHANICAL DRAWING.

By M. N. Forney.

(*Continued from page 184.*)

CHAPTER III.

CONSTRUCTIONAL GEOMETRY.

The theory of mechanical drawing is based on the principles of Geometry, which is defined as "that branch of mathematics which investigates the relations, properties, and measurement of lines, angles, surfaces and solids." Therefore a person who has a knowledge of Geometry has a great advantage in learning drawing over one who is ignorant of it. The general truths of Geometry are deduced by a course of logical reasoning, the premises being definitions and principles previously established. The course of reasoning employed in establishing any truth or principle is called *a demonstration*. Thus in books on Geometry the truth is enunciated that "in any triangle the sum of the three angles is equal to two right angles," and the reasoning is then given at length to prove that this is true. As a knowledge of mechanical drawing will be very useful to many persons who have neither time nor opportunity to acquire a thorough knowledge of Geometry, it will be the aim in this chapter to explain some of the general truths and principles of Geometry which are essential in learning mechanical drawing, without giving the proof or the reasoning by which they have been deduced.*

These truths and principles will be illustrated and explained by a series of problems, which are to be drawn first with a pencil, and the lines should then be inked in as neatly as possible. In this way, Geometry and the practice in the use of drawing instruments will be learned simultaneously. Even though the learner may have a knowledge of Geometry, he is advised to work out the problems on paper for the exercise it will give him or her in the use of instruments. In doing this work "the greatest pains should be taken from the first to acquire the power of measuring and laying down measurements on paper with perfect accuracy, which is of the utmost importance in mechanical drawing. It is best to take the measurements with compasses or dividers from the rule or scale. This method is more likely to result in exact measurement than laying the rule or scale on the paper and marking from it." †

The definitions of terms which are used will be given in footnotes. The drawings should be made double the size or twice the linear scale of the engravings—that is, a line which is one inch long in the engravings should be drawn two inches, and one two inches in the engravings ought to be four inches in the drawings. Feet and inches are designated in the engravings by single and double accent marks—thus 4 ft. 8 in. is written 4′ 8″.

The points from which measurements are to be made or to which dimensions refer are indicated by caret marks thus <———>, as shown at *c d* at the foot of fig. 24, where it is indicated that the line *c d* is 1¼ in. long, and that that is measured from the lines at the points of the carets.

As it is difficult sometimes to find prick marks of dividers or compasses, such marks and other points which are to be designated are often indicated by a small circle around them thus ⊙, or by a short line drawn at right angles to the line on which the point lies, as 1, 2, 3, 4, etc., in fig. 27.

PROBLEMS.

I.—STRAIGHT LINES.

PROBLEM 1. *To draw horizontal ‡ lines.*

Place the T-square in the position shown in fig. 21,§ and press its stock firmly against the edge of the board, and draw a line along the upper edge of the blade, and be sure that neither the stock nor blade is moved while the line is drawn. Then move the T-square either up or down the required distance that the two lines are to be separated and draw another line. Repeat this operation for each successive line.

PROBLEM 2. *To draw vertical lines.*

This was explained in the previous chapter.

PROBLEM 3. *To draw a straight line parallel to any other straight line at a given distance from it.*

First Method.—If *A B*, fig. 22, is the given line, place one side, *e f*, of the triangle *D* so as to coincide with that line. Then place the straight edge or ruler *C* in contact with the side *e g* of *D*. Then hold *C* firmly on the paper and slide *D* along the edge *e g′* of *C*, until the edge *e f* is the required distance from *A B*, as shown in fig. 23. Then draw a line along the edge *e′ f′*. In this way any number of parallel lines may be drawn.

Second Method.—If *A B*, fig. 24, be the given straight line and *c d*, 1¼ in. long, their required distance apart, with the pencil in the joint compasses, fig. 10, set the needle-point and the pencil apart a distance equal to *c d*. Then with this distance as a radius ‖ and any two points, as *e* and *f* on *A B*, as centers draw arcs ¶ of circles, 1 1 and 2 2.

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* The learner is, however, advised to acquire a thorough knowledge of Geometry, if it is possible for him to do so.

† Linear Drawing, by Ellis A. Davidson.

‡ A line in a drawing which is parallel with the lower and upper edges of the drawing-board is said to be *horizontal*. And one which is at right-angles to or square with the lower and upper edges of the board is said to be *vertical*. A line is said to be *perpendicular to* another line or surface when it is *square* with it. To say that a line in a drawing is "perpendicular" does not necessarily mean that it is *upright*, for the edges of a carpenter's or mason's square are perpendicular to or square with each other in whatever position the square is placed. *Horizontal* and *vertical* lines are *perpendicular* to each other. If a line is drawn at right-angles to or square with another which is inclined, they are also said to be *perpendicular* to each other. Thus *C′ C* in fig. 36 and *E C* in fig. 37 are both perpendicular to *A B*.

A line is *parallel* with another when they both extend in the same direction and when they are equally distant from each other through their whole extent. Thus the ruled lines on writing paper and the metal rails on a railroad are parallel.

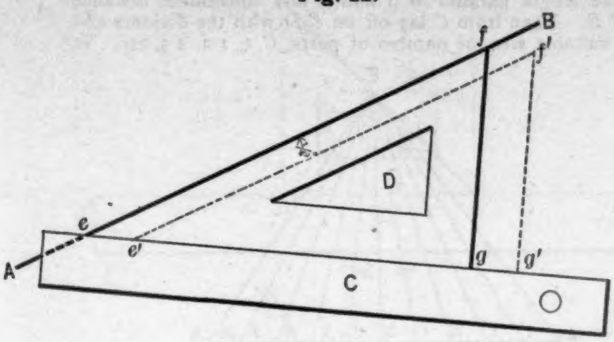
§ See the April number of the Journal.

‖ A *radius* is the distance from the centre to the circumference of a circle.

¶ An arc of a circle is a part of the circumference of a circle, as, for example, 1 1 and 2 2, fig. 24.

Draw the line $G H$ tangent* to 1 1 and 2 2. The straight line $G D$ will then be parallel to $A B$, and at the given distance $C e$ equal to $c d$ from it.

Fig. 22.



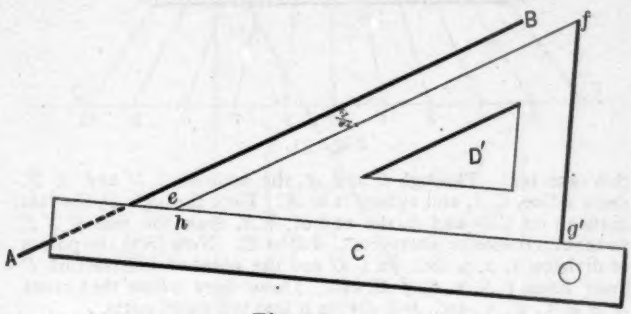


Fig. 23.

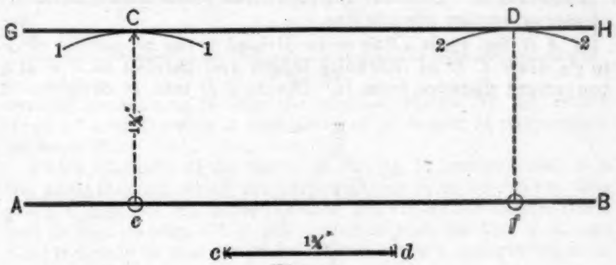


Fig. 24.

Problem 4. *To draw a straight line through a given point and parallel to a given straight line.*

First Method.—If C, fig. 25, is the given point and $A B$ the given straight line, then from C as a center, with $C D$ as a radius, draw an arc, 1 1, touching $A B$ at D; and with the same radius from any convenient point, F on $A B$ as a centre, draw the arc 2 2. Draw the line $G H$ through the point C and tangent to or touching the arc 2 2. $G H$ will then be parallel to $A B$.

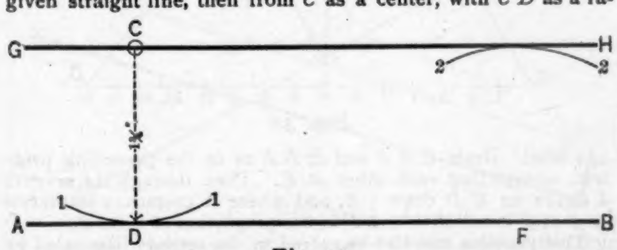


Fig. 25.

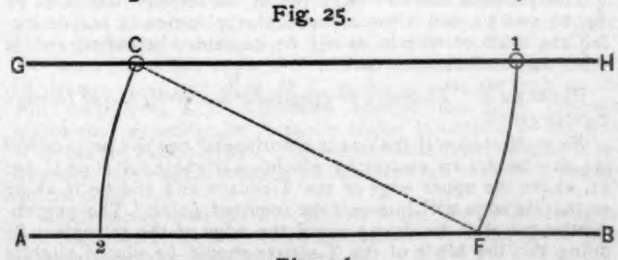


Fig. 26.

Second Method.—If C, fig. 26, is the given point and $A B$ the given line, then from C as a centre, with any radius, as $C F$, draw the arc 1 F crossing or intersecting the line $A B$ at F. From F as a center with the same radius, draw the arc 2 C. With the dividers or compasses take the distance C 2 and set it off from F on the arc F 1. Through the points C and 1 draw $G H$, which will be parallel to $A B$.

Problem 5. *To bisect, or divide in two equal parts, a straight line of a given length.*

First Method.—Supposing the line $A B$, fig. 27, is 6 in. long, it is best to define its length exactly by drawing two short lines square across it at A and B, and exactly 6 in. apart. Then set the points of the dividers, fig. 17, apart, so that the distance be-

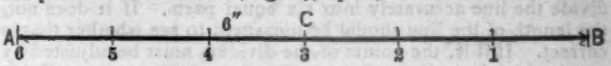


Fig. 27.

tween them, measured by the eye, is as nearly as possible equal to half the length of $A B$, or 3 in. Then place one of the points on the point at B, where the lines cross each other, and try by stepping off from that point whether twice the distance between the points of the dividers is exactly equal to the length of $A B$. If it is not, separate the points more or less, until by trial it is found that the distance between them is just equal to half the distance between A and B, and then prick a small hole in the paper at C, to mark the point of division.

An easier method is to set the points of the dividers by a rule or scale, so as to take half the length of $A B =$* 3 in., and then by stepping off from B ascertain whether this measurement is precisely equal to half the length of $A B$. If it is not, see whether $A B$ is exactly of the required length, and if it is, then adjust the points until they are just equal to half the length of $A B$.

Second Method.—With a radius somewhat greater than half the length of $A B$, fig. 28, and from A as a center, first draw arcs of a circle, 1 1 and 2 2. Then place the needle-point on B and draw arcs 3 3 and 4 4 so as to cross or intersect each other as represented. Then draw a straight line, $D E$, through the

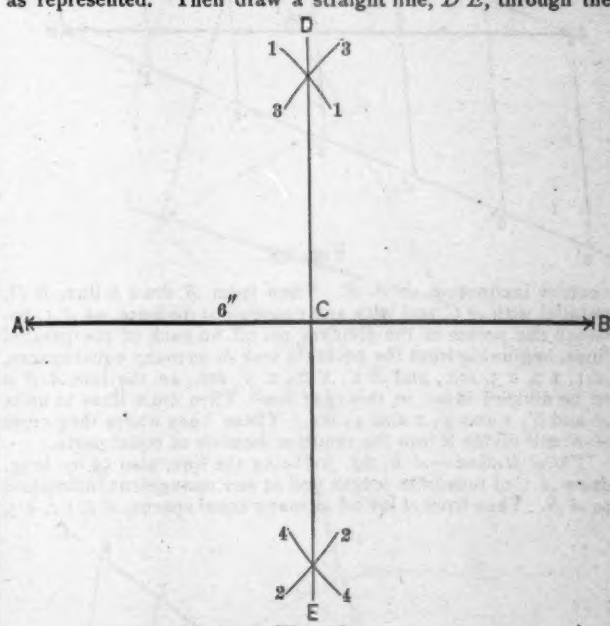


Fig. 28.

points of intersection of the arcs. This line will divide or "cut" the line $A B$ at C into two equal parts. Before drawing the line $D E$ it is best to mark the points of intersection† of the arcs exactly by pricking a small hole in the paper where they cross each other.

Problem 6. *To divide a straight line of a given length into any proposed number of equal parts.*

First Method.—If the line $A B$, fig. 27, is, say, 6 in. long, and it is to be divided into six equal parts, set the points of the dividers apart a distance as nearly equal to one-sixth of the length of the line as it is possible to determine by the eye. Then set one point on the intersection of the short line with $A B$ at B

* Tangent means touching. A line tangent to a circle touches it at one point only—that is, it does not cross or intersect it.

* The sign = means "equal to," and will be used hereafter in these articles.
† The "*intersection*" of two lines is the point where they cross each other.

and step off on *A B* six divisions, being careful to handle the dividers very lightly, so as not to make any holes in the paper. It can thus be determined whether the distance between the points will divide the line *A B* exactly into six equal parts. If it does not the points must be separated more or less until by repeated trials it is found that the space between them is just equal to one-sixth of the length of *A B*. When the length of the subdivisions is thus ascertained exactly, small marks should be pricked on the line *A B* and short lines drawn through them to indicate the points of division.

A quicker way of doing this is to divide the length of the line by the number of divisions—in the example six—and then take with the dividers the measurement thus indicated from a rule or scale, and then by trial ascertain as before whether it will divide the line accurately into six equal parts. If it does not, the length of the line should be measured to see whether that is correct. If it is, the points of the dividers must be adjusted by repeated trials until the space between the points will subdivide the line correctly.

If there are many divisions and if their *number* can be divided equally it is best first to divide the line into a few divisions and then subdivide these. Thus the line *A B*, which is 6 in. long, could be laid off first into two or three equal parts, each 3 or 2 in. long, and these might then be subdivided into two or three subdivisions, each 1 in. long.

In doing such work the learner must be careful first to lay off the line *A B* of just the right length and then adjust the points of his dividers with the utmost precision.

Second Method.—*A B*, fig. 29, being the required line, $5\frac{5}{8}$ in. long, from *A* draw a line, *A C*, of indefinite length at any con-

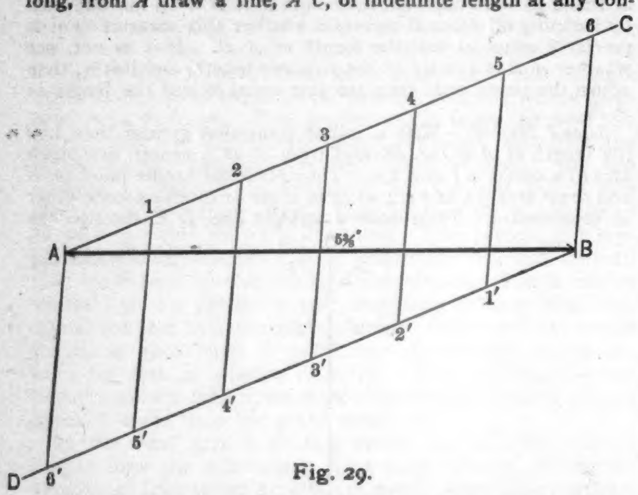


Fig. 29.

venient inclination to *A B*. Then from *B* draw a line, *B D*, parallel with *A C*, and with any convenient distance, as *A* 1, between the points of the dividers set off on each of the parallel lines, beginning from the points *A* and *B*, as many equal spaces, *A* 1, 1 2, 2 3, etc., and *B* 1', 1' 2', 2' 3', etc., as the line *A B* is to be divided into; in this case six. Then draw lines to unite *A* and 6', 1 and 5', 2 and 4', etc. These lines where they cross *A B* will divide it into the required number of equal parts.

Third Method.—*A B*, fig. 30, being the line, also $5\frac{5}{8}$ in. long, draw *A C* of indefinite length and at any convenient inclination to *A B*. Then from *A* lay off as many equal spaces, *A* 1, 1 2, 2 3,

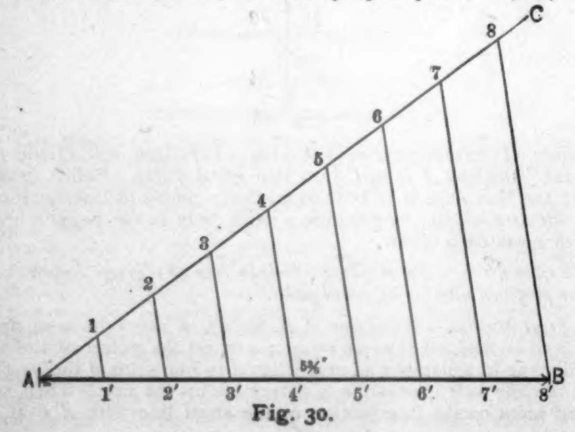


Fig. 30.

etc., as the line *A B* is to be divided into; in this case eight. Draw a line, 8 *B*, through 8, the last division on *A C*, to *B*, the end of *A B*. Then draw lines parallel to 8*B* through the points 7, 6, 5, 4, etc. Where these lines cross *A B* at 7', 6', 5', etc., they will divide it into the proposed number of equal parts.

Fourth Method.—*A B*, fig. 31, being the line, draw *C D* of indefinite length parallel to it and at any convenient distance from *A B*. Then from *C* lay off on *C D* with the dividers and of *any* suitable size the number of parts, *C* 1, 1 2, 2 3, etc.; in

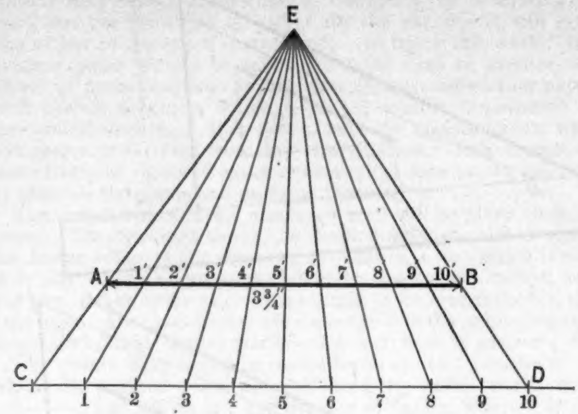


Fig. 31.

this case ten. Through *C* and *A*, the ends of *C D* and *A B*, draw a line, *C A*, and extend it to *E*. Then through *D*, the last division on *C D* and *B*, the end of *A B*, draw the line *D B E* so that it crosses or intersects *C A E* at *E*. Now from the points of division 1, 2, 3, etc., on *C D* and the point of intersection *E* draw lines 1 *E*, 2 *E*, 3 *E*, etc. These lines where they cross *A B* at 1', 2', 3', etc., will divide it into ten equal parts.

PROBLEM 7. *To divide a straight line proportionally to the divisions of another straight line.*

If *A B*, fig. 32, is a line to be divided in the proportion of $\frac{7}{15}$ to $\frac{8}{15}$, draw *C D* of indefinite length and parallel to *A B* at a convenient distance from it. Divide *C D* into 15 divisions of

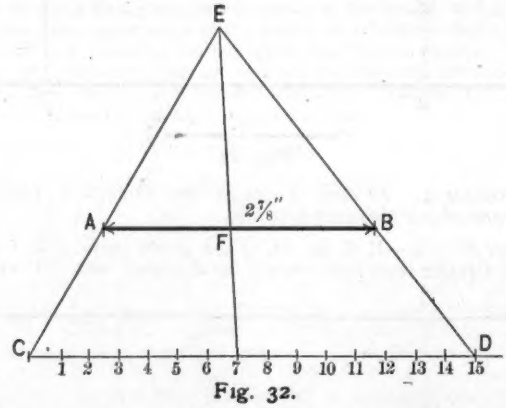


Fig. 32.

any size. Draw *C A E* and *D B E* as in the preceding problem, intersecting each other at *E*. Then through the seventh division on *C D* draw 7 *E*, and where it crosses or intersects *A B* at *F* it will divide *A B* in the proportion of $\frac{7}{15}$ to $\frac{8}{15}$.

This problem can also be solved by the method illustrated by fig. 29 and 30, and it has a practical application in proportioning the teeth of wheels, as will be explained hereafter, and in other mechanical construction.

PROBLEM 8. *To draw a perpendicular to a straight line through a given point.*

First Method.—If the line is a horizontal one the perpendicular can be drawn easiest by placing a triangle, *A B* or *C*, fig. 21, above the upper edge of the T-square and sliding it along so that its edge will intersect the required point. The perpendicular can then be drawn along the edge of the triangle. In doing this the blade of the T-square should be placed slightly below the line, so that the perpendicular may intersect it or be drawn so that the two lines will meet each other. If the line is a vertical one, a perpendicular may be drawn to it with the T-square.

Second Method.—If a line, *A B*, fig. 33, has been drawn along the long side of a 45 degree triangle *E*, in the position shown, then by holding the blade of the T-square or the straight-edge *C* securely in its place, and reversing the position of the triangle

as indicated by the dotted lines E', and drawing a line along the edge $A' B'$, it will be perpendicular to $A B$.

If the line is drawn along the edge $A B$ of the 30 and 60-degree triangle D in the position shown in fig. 34, then by re-

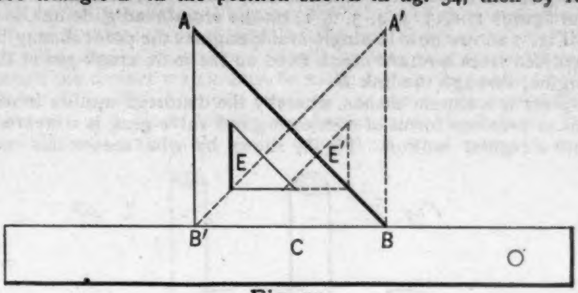


Fig. 33.

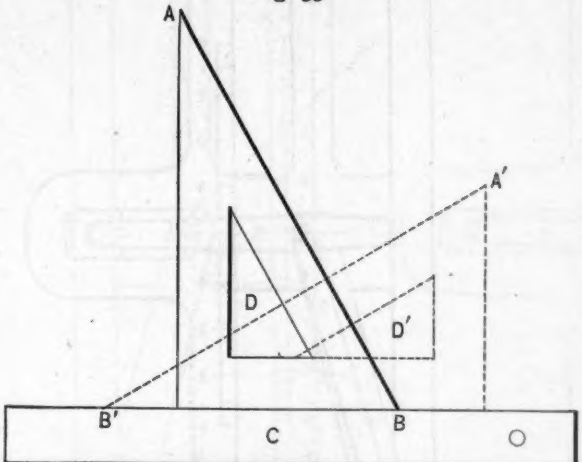


Fig. 34.

versing or turning it into the position shown by the dotted lines D' and drawing a line along $A' B'$ it will be perpendicular to $A B$.

Third Method.—If the line $A B$, fig. 35, is inclined, and a is the point through which the perpendicular is to be drawn, then place a triangle, E, in the position shown by the dotted lines, and so that its edge $C' D$ will coincide with the line $A B$, and hold it firmly in that position. Then place a straight-edge, C,

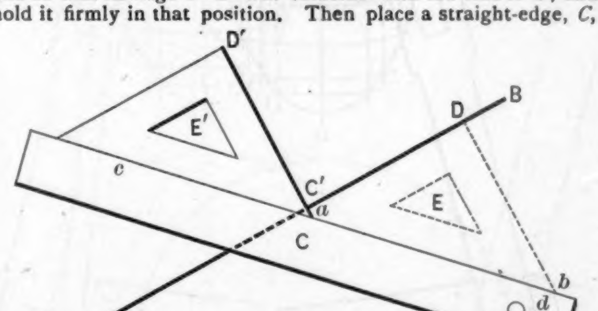


Fig. 35.

or another triangle so that its edge $c d$ bears against the edge $a b$ of E. Then hold C securely in its place and slide E along $c d$ to the position shown by full lines at E', and its edge $D' C'$ intersects the point a on $A B$. The perpendicular may then be drawn along the edge $D' C'$ so as to pass through a. It will make very little difference whether the point through which the perpendicular is to be drawn is outside of the line $A B$, as, for example, at D', because in that event all that is required is to slide the triangle E until its edge intersects the required point.

A little practice in drawing perpendicular lines with triangles will teach the student more of the method of using them than he will learn from any description.

Fourth Method.—If the point C, fig. 36, through which the perpendicular is to be drawn is on the proposed line $A B$, and near its middle, draw from C as a center with any convenient radius, as $C a$, two short arcs, a and b, crossing $A B$. Then with a and b, the points of intersection of these arcs with $A B$, as centres, and with a radius, $a C'$, greater than $C a$ describe* arcs 1 1 and 2 2 intersecting each other at C'. A line $C C$ drawn through C' and C will be perpendicular to $A B$.

* To *describe* an arc means to draw it.

Fifth Method.—If the point C', fig 36, through which the perpendicular is to be drawn, is not on the straight line $A B$—

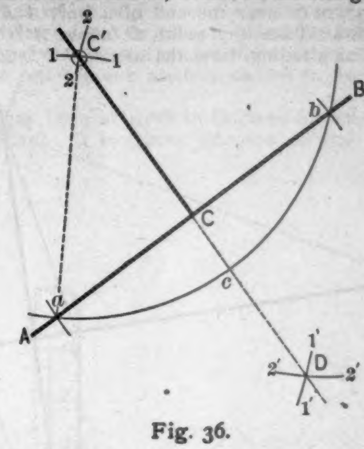


Fig. 36.

then with a radius, $C' a$, somewhat greater than the distance $C' C$ of C' from $A B$, draw an arc, $a c b$, intersecting $A B$ at a and b. Then with a and b, the points where $a c b$ crosses $A B$, as centres, draw arcs $1' 1'$ and $2' 2'$ crossing each other at D. A line, $C' D$, drawn through C' and D, the point of intersection of $1' 1'$ and $2' 2'$ will be perpendicular to $A B$.

Sixth Method.—If a point is at or near the end of a line and it is horizontal or vertical, a perpendicular can be most conveniently drawn to it through the given point with a

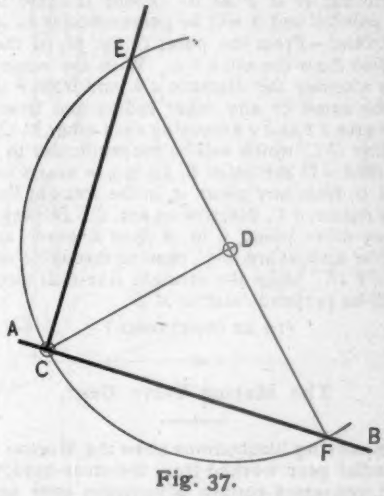


Fig. 37.

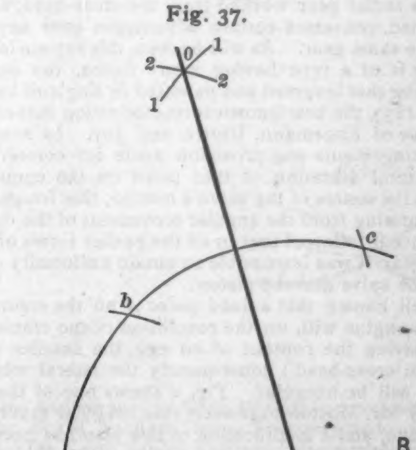


Fig. 38.

T-square and triangle in the manner explained in the last chapter. If the line is inclined, as in figs. 37, 38 and 39, it can

be done with two triangles in a similar manner to that described in the third method of solving Problem 8, and illustrated by fig. 35.

Seventh Method.—A perpendicular can be drawn through a point, *C*, fig. 37, at or near the end of a line, *A B*, with compasses as follows: Take any point, *D*, above *A B* as a center, and with *D C* as a radius draw the arc *E C F*, cutting *A B* at

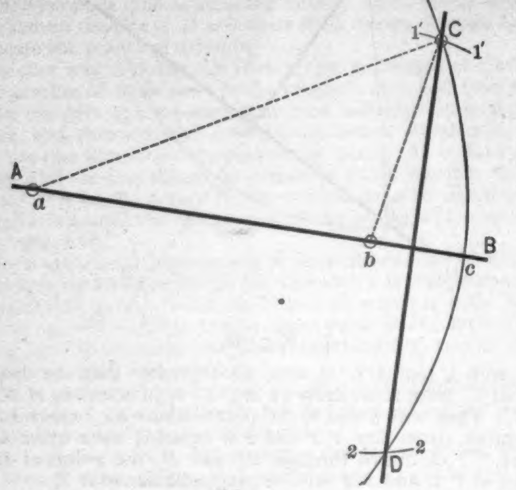


Fig. 39.

C and *F*. Draw the line *F D* through *F* and *D* and extend it so that it will cut *E A F* at *E*. From *E* draw the line *E C* through the point *C* and it will be perpendicular to *A B*.

Eighth Method.—From the point *C*, fig. 38, in the line *A B*, with any radius draw the arc *a b c*. With the same radius lay off from *a* as a center the distance *a b*, and from *b* the distance *b c*. With the same or any other radius and from *b* and *c* as centers draw arcs 1 1 and 2 2 crossing each other at *O*. Through *O* draw the line *O C*, which will be perpendicular to *A B*.

Ninth Method.—If the point *C*, fig. 39, is nearly over the end of the line *A B*, from any point, *a*, in the straight line *A B* as a center, and a radius, *a C*, describe an arc, *C c D*, passing through *C*. From any other point, *b*, in *A B* as a center, and *b C* as a radius, describe a short arc, 1′ 1′, passing through *C* and another, 2 2, cutting *C c D*. Draw the straight line *C D* through *C* and *D*, and it will be perpendicular to *A B*.

(TO BE CONTINUED.)

The Morton Valve Gear.

THE accompanying illustrations show the Morton valve gear, which is a radial gear worked from the cross-head, and which, it is claimed, possesses certain advantages over any previous form of the same gear. As will be seen, this system in reversing valve gear is of a type having many forms, the earliest one known being that invented and patented in England by Matthew Punshon, 1839, the best-known forms following that of Punshon being those of Engemann, Brown and Joy. In none of these earlier arrangements was provision made for correcting the irregular lateral vibration of that point on the connecting-rod which was the source of the valve's motion, this irregular lateral vibration arising from the angular movement of the connecting-rod. Hence it followed that in all the earlier forms of this class of valve gear it was impossible to obtain uniformity of motion between the valve and the piston.

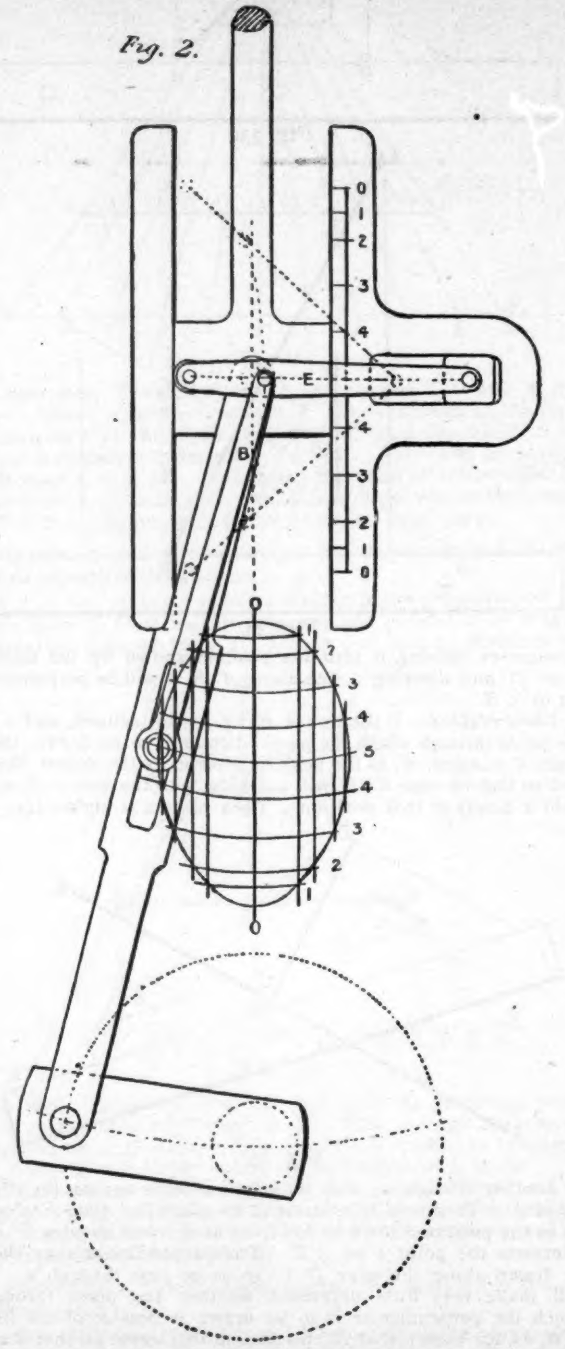
It is well known that a fixed point *A* on the connecting-rod of a steam-engine will, on the revolution of the crank, describe a figure having the contour of an egg, the smaller end being nearest the cross-head; consequently the lateral vibrations of that point will be irregular. Fig. 2 shows one of the methods adopted by Mr. Morton to convert this irregular movement into a regular one, and a modification of this plan has been generally applied to the marine and locomotive engines to which Morton's system of valve gear has been fitted.

Confining the description to fig. 2, it will be observed that the point *A* is connected to the piston-rod cross-head through the link *B* and lever *E*; consequently *A* becomes a movable point or center in contradistinction to a fixed point, and on the rotation of the crank the movement of the point *A*, actuated by the piston, is so controlled that the figure described by it becomes a regular oval figure, having a major axis equal in length to the actual travel of the movable point. The ordinates, 1, 2, 3, 4, 4, 3, 2, 1, may be described crossing the figure with a radius equal to the length of the link *B*, and are equal in length at either end of the figure for every corresponding increment of the piston's travel from either end of its stroke, as indicated by the figures 1, 2, 3, 4, 4, 3, 2, 1, on the cross-head slide-bar.

Fig. 3 shows how in single-crank engines the point *A* may be actuated from a return crank fixed on the main crank-pin of the engine, through the link *B*.

Here is a simple means whereby the distorted motion inherent in previous forms of connecting-rod valve gear is converted into a regular motion. Fig. 4 shows by what means this cor-

Fig. 2.



rected connecting-rod motion may be conveyed to the fulcrum center *G* of the radial lever *F*. Instead of the movable point sliding on the center-line of the connecting-rod, it becomes the center *A* of a radiating spanner or crank *P*, centered in a projection *P′* on the connecting-rod, and actuated from the piston, as described in fig. 2, the point *A* radiating equally across the center line of the connecting-rod instead of sliding upon it. Now on revolving the crank the movable point *A* will follow an oval path similar to that described in the preceding figure, but the major axis of the figure will have become a segment of a circle, having a radius equal to the length of the lever *F*, which is attached at *G* to the link *C*, vibrating from the fixed center *K*.

On revolving the crank of the engine it will be seen that for every movement of the piston from either end of its stroke the center *G* has a corresponding movement to that of the piston, and equal on either side of its central position, which is on a line drawn parallel to the center line of the engine, and coinciding with the position of the vibrating link *C*, when the engine is at either end of its stroke. It will be seen that a line drawn through the crosses which may be made by a pencil point at *C* in lever *F* (see fig. 4), in one revolution of the engine would be as the arc of a circle having a radius equal to the link *B*. It should here be stated that if the amount of relative travel imparted to the movable point *A* be either more or less than that required to obtain the true geometrical oval path thereof, a line drawn through the crosses, which would then be made by a pencil point at *G*, would form a curve partaking of the nature of an angled ogee line, as *a b*, when the travel is too little, and as *c d*, when the travel is too great, the mathematically correct amount of relative travel in the point *A* producing the crosses on a true curve, *e f*, as shown in fig. 4 and fig. 5. The lever *F* may be prolonged beyond the point *A*, and connected to the cross-head of the piston-rod by the link *B* at the point *D*.

Other arrangements might be shown by means of slight modifications, which will readily suggest themselves to any one familiar with the subject, but it is believed that the illustrations given will be sufficient to show the general principles of this gear and the advantages offered by this device.

The gear has been fitted to an outside-cylinder locomotive by an arrangement which will be easily understood. One of the advantages claimed for it in a locomotive is that the whole motion is outside of the engine, and easily reached for oiling and repairs. The return-crank method, shown in fig. 3, is used in this case.

This gear has been at work in England for some years with favorable results. It has been adopted on the Inman Line Steamer *Ohio*, and by several other steamship companies. It is in use on the North London Steam Tramway and on some locomotives on the North British Railway. On a triple-expansion marine engine it is claimed that at least 10 per cent. is saved in space and cost. Mr. Robert Bruce, of 70 Bishopsgate Street Within, London, is Engineer in charge of this invention.

Fig. 3.

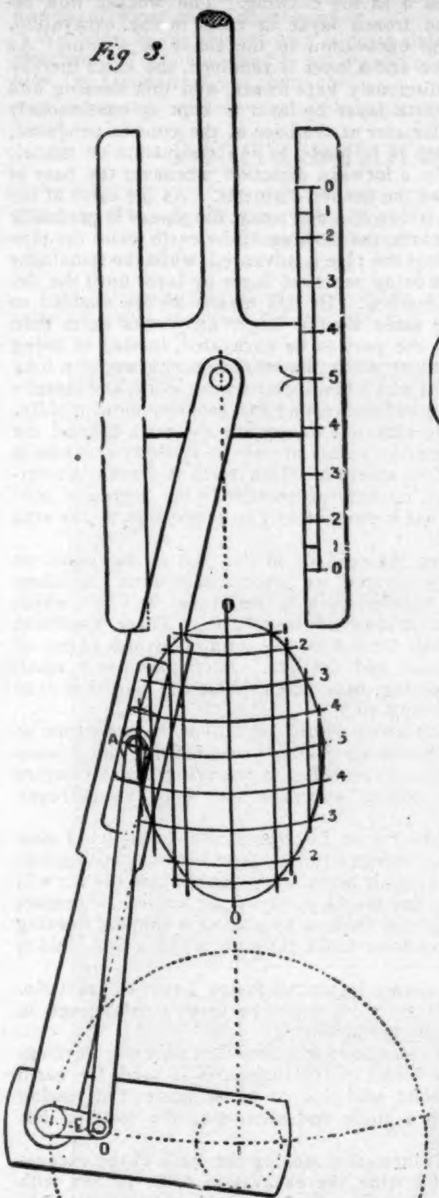


Fig. 4.

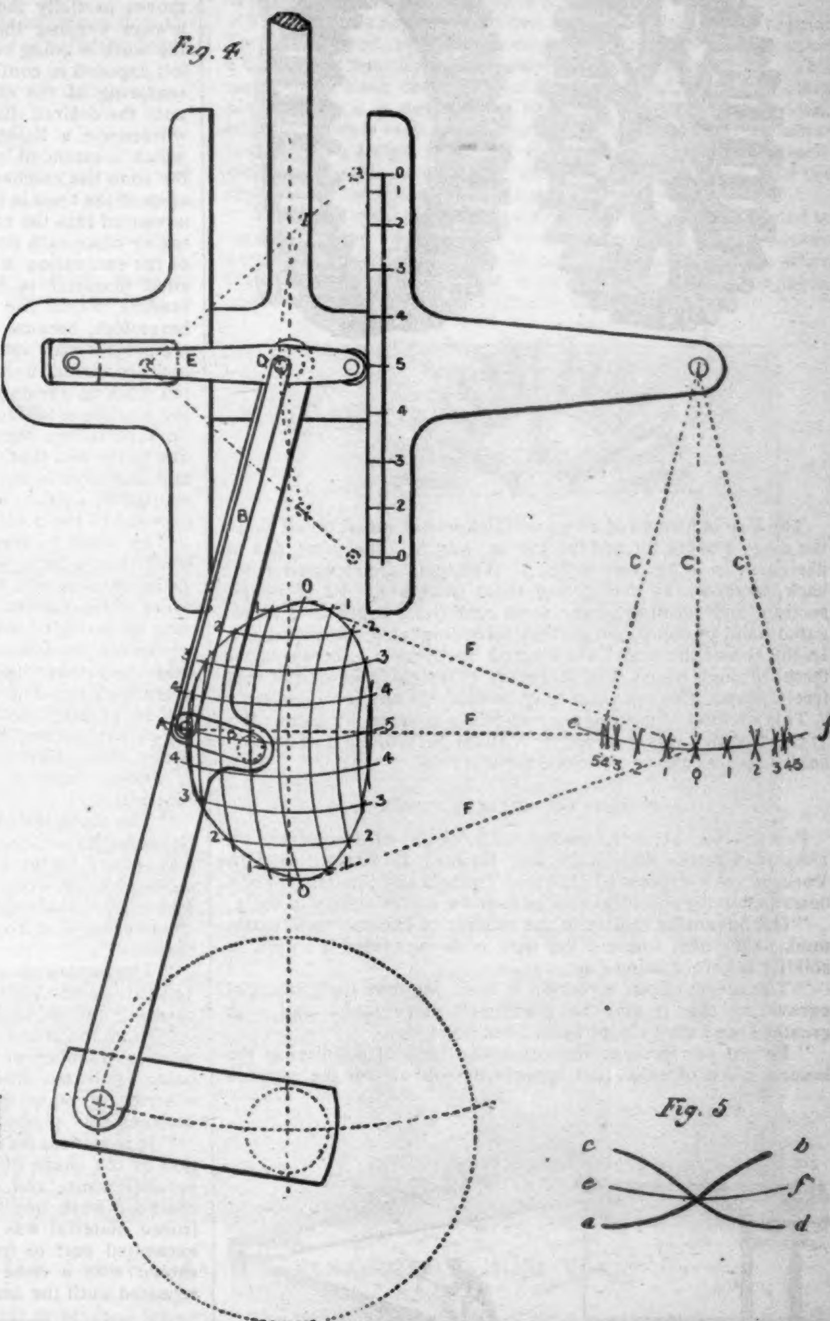


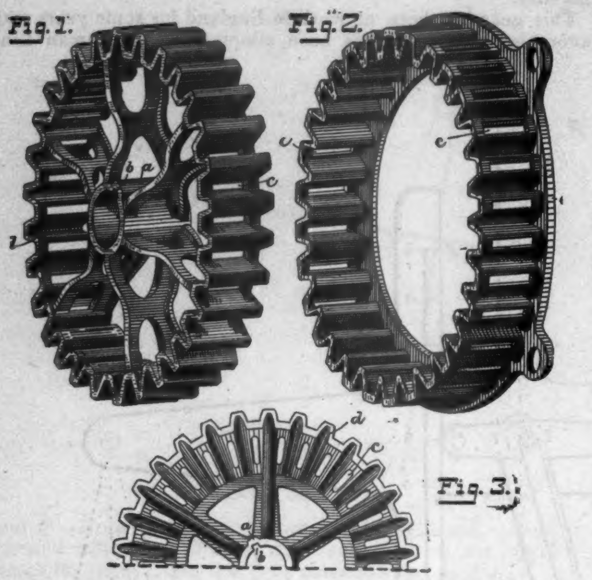
Fig. 5

Recent Patents.

I.—MALLEABLE IRON GEAR-WHEELS.

THE accompanying illustrations show a new form of malleable iron gear-wheel, which has been devised to meet the objec-

tions generally made to malleable iron gears, which are that certain parts being thicker than others they cannot be thoroughly annealed, and also that a malleable casting shrinks more in cooling than any ordinary casting. In the illustrations fig. 1 is a perspective view of the ordinary spur gear-wheel; fig. 2 a gear-wheel with flange for bolting to the arms of a larger wheel, and fig. 3 is a half view of the bevel gear showing one form of arms adopted.



The hub is formed of an equal thickness of metal on all sides, the ridge *a* being formed for the keyway *b*. The arms may be designed, as in fig. 1 or in fig. 3. The teeth are recessed at the back, as shown at *d d*, giving them something of a U-shaped section, and forming of the teeth and rim a continuous corrugated band of metal, the section providing also for shrinkage. In the rim of the wheel are formed openings *c c*, between the teeth, through which dirt, straw, or other clogging matter may freely pass. The openings may be made in any form desired.

This method of casting gear-wheels is covered by patent No. 415,755, which was granted to William N. Whiteley, of Springfield, O., under date of November 26, 1889.

II.—PROCESS OF BUILDING TUNNELS.

Patent No. 417,288, issued under date of December 17, 1889, to Charles Sooysmith and Edward L. Abbott, of New York, is for a Process of Building Tunnels and Shafts. This is described in the specifications, as follows, and is shown in fig. 4:

"Our invention relates to the process of excavating in earth, mud, or the like, wherein the part to be excavated is frozen to solidify it before being dug.

"The object of our invention is to so improve the process of excavating that it may be performed more easily and with greater speed than has hitherto been done.

"Before our present invention the idea of solidifying the inner surface of excavated tunnels by cold air for the purpose

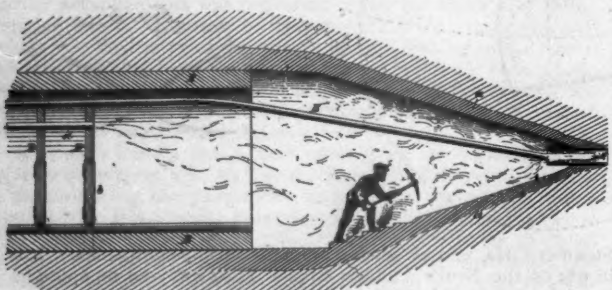


Fig. 4.

of hardening the part to be dug had already been carried out; but in that case the surface or wall at the inner end of the excavation was practically flat, or the wall left vertical.

"In carrying out our invention the excavation is kept in the form of a cone or pyramid, with the apex in the direction in which the excavation is being made. In order to freeze or solidify the earth to be excavated, we place a pipe or chamber *A* at the apex of the excavated cone, as shown in fig. 4. This pipe or chamber is supplied with cold air or other freezing-fluid by means of a pipe *B*, that is connected with a suitable source from whence the freezing-fluid may be supplied to the pipe *A*. The cold air or other freezing-fluid, being passed to the pipe *A*, freezes the earth in the vicinity of said pipe, and then passes from the pipe *A* back through the excavation, as indicated by the arrows in the drawing. If any other fluid than air is used, it is necessary to conduct it away in a separate pipe. This cold air freezes or solidifies the earth composing the inner wall of the cone to a certain depth, as indicated by the heavy section lines *a* in the drawing. The worker now removes partially the frozen layer of earth in the excavation, always keeping the excavation in the shape of a cone. As the work is going on and a layer is removed, the earth thereby left exposed is continuously kept frozen, and this freezing and removing of the earth layer by layer is kept up continuously until the desired diameter at the base of the cone is produced, whereupon a lining *B* is made in the excavation or tunnel, which is extended in a forward direction whenever the base of the cone has reached the desired diameter. As the earth at the apex of the cone is frozen and dug away, the pipe *A* is gradually advanced into the earth, the freezing of the earth about the pipe taking place each time the pipe is advanced, while the remainder of the excavation is being removed layer by layer until the desired diameter is reached. By this means we are enabled to remove within the same time a larger amount of earth than heretofore, because the part to be excavated, instead of being a mere flat wall against which the workmen operate, is a long inclined surface upon which the operators can work, and thereby the work of freezing and excavating can progress more rapidly, the workmen taking care not to remove the earth beyond the limit of frozen material. This ability to speedily excavate is due to the fact that the extent to which earth is frozen in a certain direction is not in direct proportion to the degree of cold applied to a point, but is more nearly in proportion to the area exposed to the cold.

"In order to keep the cold air in the part of the tunnel or shaft that is being excavated, we place one or more partitions *D* in or near the finished part of the tunnel or shaft, which prevent the sudden outflow of the cold air. These partitions may be provided with doors *b* for the admission and egress of workmen, implements, and the like. A comparatively small tube *d*, or other opening, may extend from the partition *D* to carry back the returning air.

"In practice the freezing will be kept up at the same time as the excavation and lining are taking place, making the process continuous. Care should be taken in removing the thin layers of frozen material not to approach too near the unfrozen material.

"The air in the heading or freezing pipe or chamber *A* may be cooled by ordinary refrigerating apparatus in any convenient way, either by the cold-air machine, in which case the air will come directly from the machine, or by air cooled by contact with coils containing cold fluid, or by placing within the freezing chamber or pipe *A* coils or tanks through which a cold fluid is passed.

"The apparatus shown in United States Letters Patent No. 340,161, dated April 20, 1886, might be used to advantage in carrying out our improved process.

"From the above description it is seen that only one freezing-pipe or chamber or bunch of freezing-pipes is used, the earth being excavated around said pipe or bunch, instead of placing a series of pipes in a circle and excavating the material left between said pipes.

"It is evident that instead of making the walls of the excavation in the shape of a cone, the excavation could be left with parallel walls, and if the earth at the side of the freezing-chamber were not frozen to the desired diameter, after the frozen material was removed the cold air could be let into the excavated part to freeze the side thereof, similarly to the use shown with a cone or conical form. This process may be repeated until the desired diameter is obtained."

Red Rock Bridge.

On March 25 last the west half of the Red Rock Cantilever Bridge was completed. It will be remembered that this is the Atlantic & Pacific Railroad crossing of the Colorado River, a few miles below the dining station at the Needles, Cal.

This bridge is a through cantilever with a span of 660 ft. center to center of main pins. The shore and river arms are 165 ft. center to center, respectively, and the suspended span has a length center to center of 330 ft., giving a total length of 990 ft. When completed this bridge will supersede the Tyrone Cantilever as the longest cantilever span in this country,

and no doubt will in its turn in a few months be surpassed by the Memphis Bridge.

The erection is being accomplished with but one traveler, and in consequence but one-half of the bridge can be built at a time. On March 25 the tearing down of the traveler commenced; it was transferred to the east side of the river, and the second half of the bridge is now being rapidly erected.

The date for completion has been set at May 1, and every effort is being made to finish the work if anything before this date, as about ten miles of track now being used by the railroad is in ever increasing danger of being washed away by high water and the traffic of the road stopped.

We hope to be able to give a more detailed account of the structure and of the method of adjustment of the suspended span after the bridge has been completed.

Manufactures.

Electric Transfer-Table, New York Central & Hudson River Railroad.

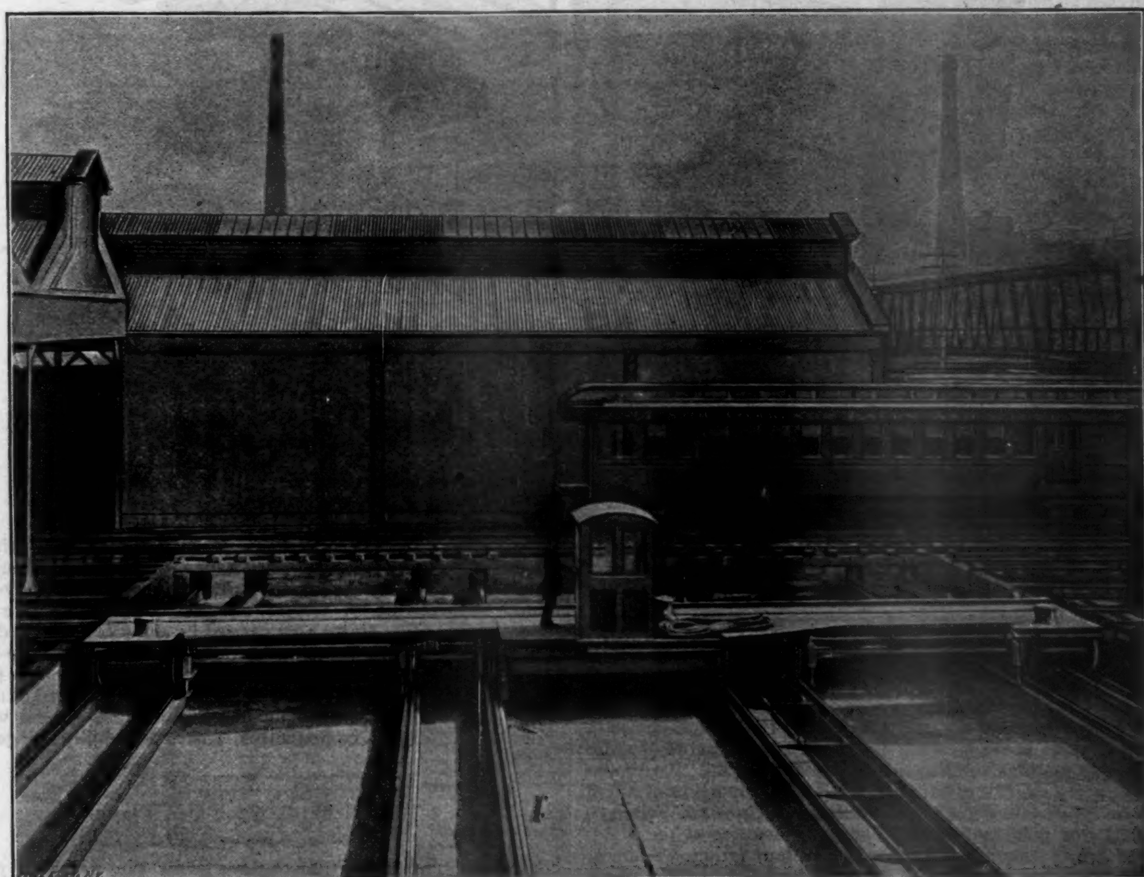
THE accompanying illustration shows an electric transfer-able, recently installed by the Sprague Electric Railway & Motor Company for the New York Central & Hudson River Railroad.

This table differs from the earlier ones chiefly in the electric motor, which is of 15 H.P. instead of 7½ H.P., and also in the contact arrangement. The contact is obtained from a couple of heavy copper wires stretched taut about 3 ft. apart over the second of the four parallel tracks, the wire being carried on insulators fixed to light cast-iron cross-beams, so as to be a few inches above the rails. The conductors are kept taut under all changes of temperature by springs at one end. Over these wires two contact rollers travel beneath the table, being kept in contact by gravity only. In the Altoona electric transfer-table, installed by the Sprague Company, there is an outer contact maintained by springs, while at the Waukesha transfer-table, installed by the Sprague Company for the Wisconsin Central Railroad, there is an overhead contact. The current used is only 220 volts, and hence, while not wholly pleasant to take in one's body, it is in no way dangerous. The current is taken from the same dynamo that furnishes light for the station. The full current capacity of the table motor is 60 ampères.

The speed of the electric motor is governed by a switch which throws the winding of the field into different combinations, thus altering the current, maintaining a practically constant strength of field without the use of any wasteful resistance. The control over the speed of the motor is perfect, and no complicated nest of gearing for changing speed is required.

The motor is supported at one end, according to the regular Sprague method, by double compression springs playing upon a bolt which rests upon the platform of the transfer-table. This method has been developed in street railroad work and other places where it is desirable to start slowly under a heavy load, and has proved very satisfactory. At the other end the motor is sleeved on a rigid support. By means of this flexible attachment all danger of stripping the gears is eliminated, and the strain upon the gears is always a progressive one.

The advantages of electric power for this work are claimed to be great. The equipment is very much lighter than if steam-power were used, and there is no expense of operation when the table is not in use. One man can easily handle the table, and more conveniently and directly than with steam.



ELECTRIC TRANSFER TABLE, GRAND CENTRAL DEPOT, NEW YORK.

The two end capstans shown on the table are fixed; the center one is revolved in either direction by a simple clutch-gear. It is used, of course, for working cars on or off the table without locomotive power.

The capacity of the table is 100,000 lbs. Ordinary car axles, bearings, and wheels are used throughout for the running-gear, and the total cost of the table and motor complete was under $7,000. Its speed is about 150 ft. per minute, the same as the old wire-rope table which it replaced. The old pit was lengthened somewhat, and accommodates 10 tracks. The rails are carried on wooden longitudinals resting on small masonry foundation walls. The pit drains directly into the city sewers.

The table is constructed with 15-in. cross-beams and 12-in. longitudinals, thoroughly braced with a rigid lateral system. It

was designed and built by the Yale & Towne Manufacturing Company, of Stamford, Conn.

The small cabin, shown at the center of the table, is provided for the operator.

Electric transfer-tables have now been adopted by the Pennsylvania, the Philadelphia & Reading, the Chicago, Burlington & Quincy, the Wisconsin Central, and other prominent railroads, and they are now recognized as an essential feature of an extensive and well-equipped railroad yard.

Steam-Engine Foundations in the Air.

AMONG the remarkable examples of bold engineering in the great sugar refinery of Claus Spreckels, at Philadelphia, one of the most unique is the hanging or aerial steam-engine foundations. The engines used in this establishment are distributed practically all over the buildings, a large proportion of them being on upper floors. Some of these engines are bolted to iron beams or girders on second and third stories of the building, and are consequently innocent of all foundation. Some of these engines ran noiselessly and satisfactorily, while others produced more or less vibration and rattle. To correct the latter, the engineers simply suspended foundations from the bottoms of the engines, so that, in looking at them from the lower floors, they were literally hanging in the air. It would seem from this result that a foundation does service to an engine, or any machinery by its weight alone, no matter what is under it; a somewhat unexpected result.

Electric Welding in the Navy.

THE special board appointed by the Secretary of the Navy to investigate the Thomson electric welding process finds that this process will be very useful in making repairs on ship-board and for many other purposes. The report says:

"It is the unanimous opinion of the Board that in the present day of ships constructed almost entirely of metals, and in which every fitting possible is made of metal, such a system as that which has been investigated by us becomes not only desirable, but a means to economy of expense, time and labor, and would add to the efficiency of the vessel under any condition of service.

"This system of welding occupies a position of its own; it is able to do not only a large part of the work of the forge now in use, but is capable of doing much work that was hitherto considered impracticable. By its use, the large accumulation of now almost worthless boiler tubes stored at the navy-yards could be made fit for service, and the quantity of spare tubes and of many other stores now carried by ships could be reduced.

"As the classes of work at naval stations and on ship-board differ materially, the welders designed for use in the two places should be constructed for the work that will be required of them; those for use on board ship being especially designed with a view to lightness, compactness and adaptability to general work."

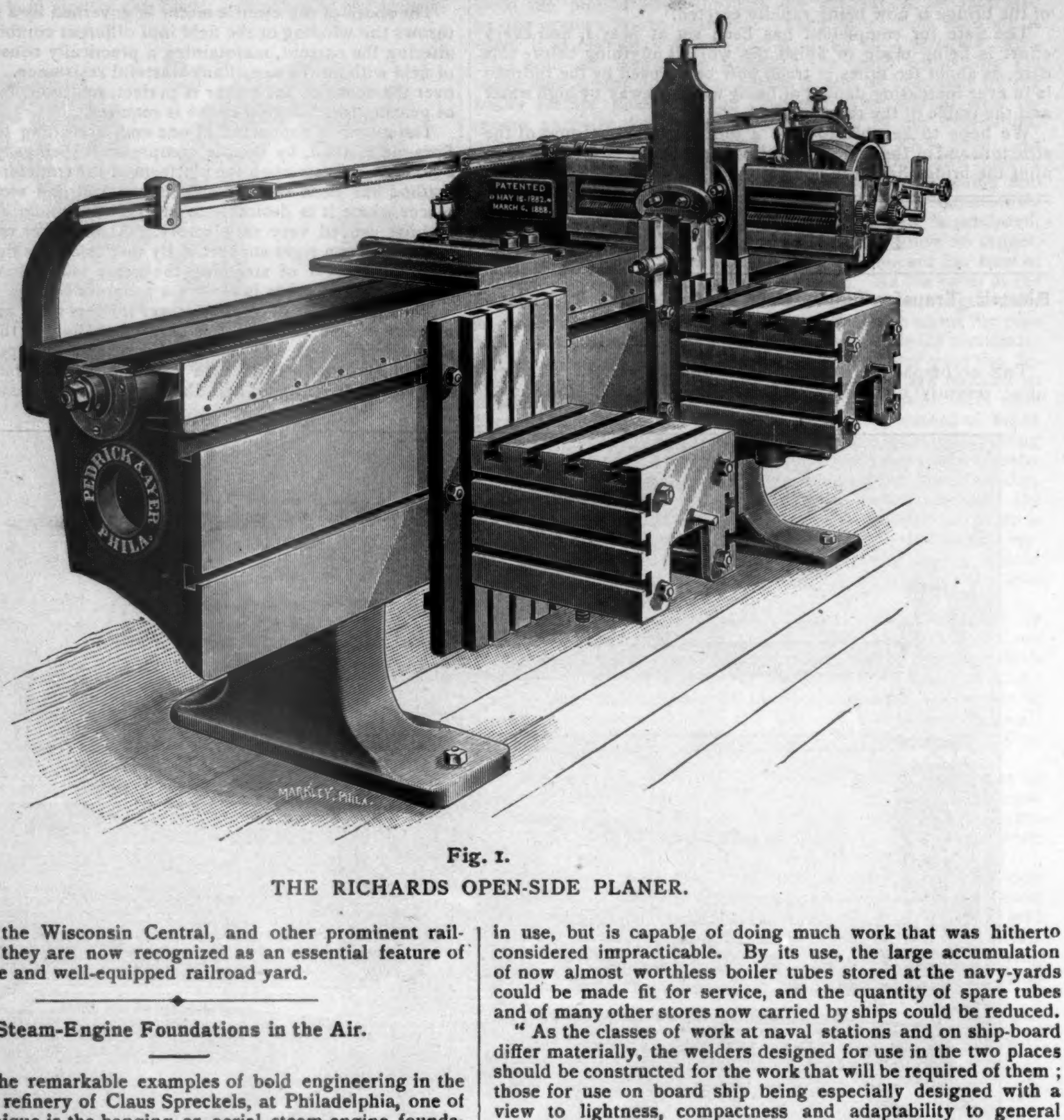


Fig. 1.

THE RICHARDS OPEN-SIDE PLANER.

The Richards Open-side Planer.

THE accompanying illustrations show the Richards patent open-side planer, a machine tool which can be used as well as an ordinary planer on ordinary work, and is also capable of a great range of work on special and difficult jobs. Its general construction and arrangement will be readily seen from the engravings.

This planer is built in different sizes, the one shown in the cut having a bed 10 ft. 6 in. long; this size machine will plane 8 ft. in length, 25 in. in width and 24 in. in height when using the square table.

Pieces 42 in. high will clear the arm when setting on the floor, and if the machine is located over a pit its capacity for difficult work is increased, and by taking advantage of the open side, pieces of unusual dimensions may be planed with comparative ease.

The screw running the entire length of the bed is driven by high-speed pulleys and shifting belts without the use of gearing, and imparts a smooth and quiet movement to the traveling carriage and arm that supports the swivel head and cutting tool.

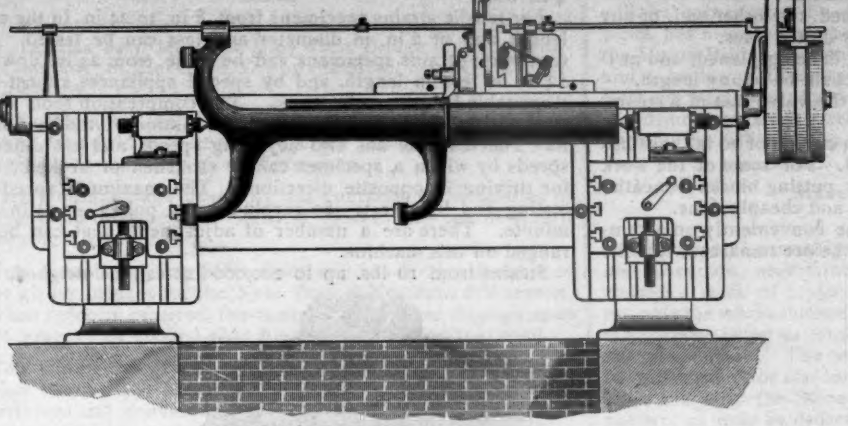


Fig. 2.

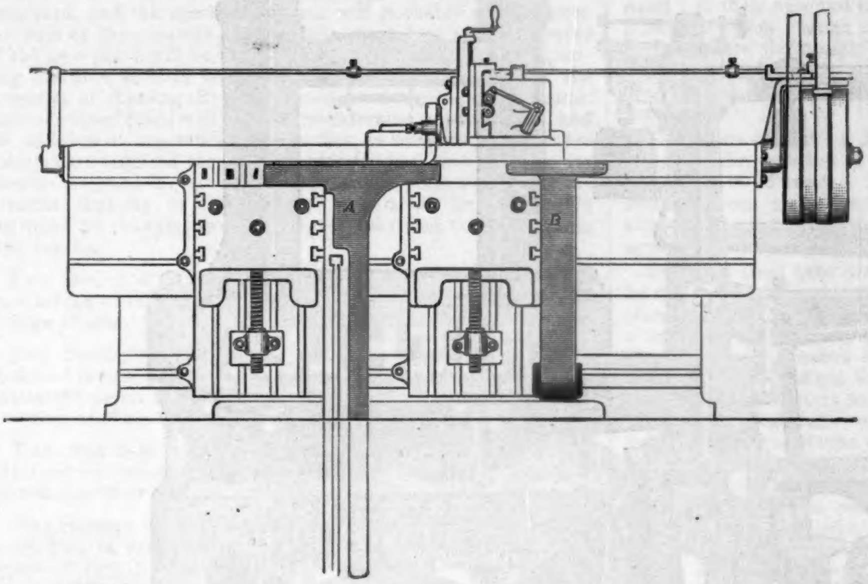


Fig. 3.

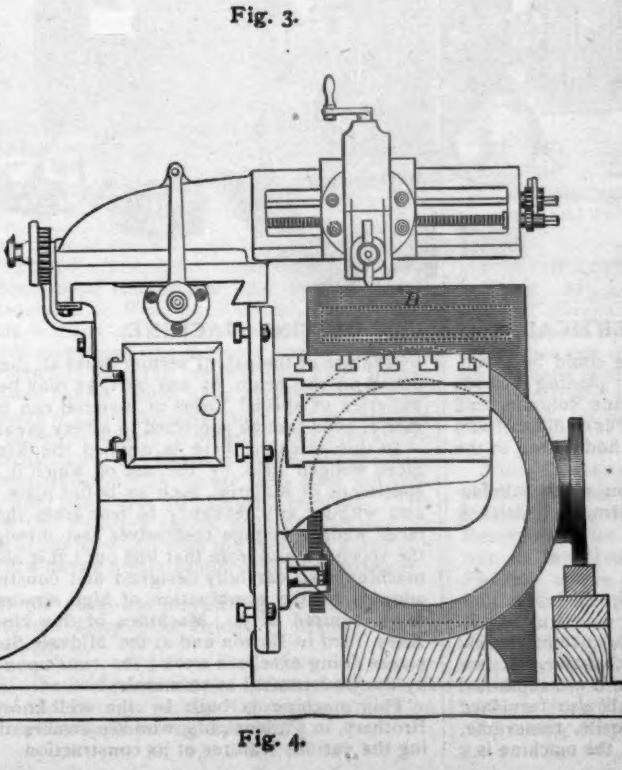


Fig. 4.

This overhanging arm is so proportioned and constructed as to ensure the requisite stiffness when used at its outer end, and is cast with or firmly bolted to the carriage or saddle, which is well gibbed to the bed of the machine.

The shifting of the belts is accomplished and the movement of the saddle reversed by means of adjustable tappets on the belt-lifting rod above the screw, and the proper speed forward and the quick return or backward movement is governed, by the relative diameters of the pulleys upon the countershaft.

The slotted plates and square tables can be set in any position along the bed, or removed entirely when planing heavy frames and castings that require more room in setting, and could not well be done at all except on large and costly machines.

The movement of the cutting tool being parallel with the bed and extending over both tables in the same direction, one of the tables may be set to take the tool thrust at the proper height, saving time in the setting and fastening of work, as well as providing a solid and convenient stop.

Pieces may be planed on one of the tables while fastening work upon the other, and when used in this way will fill the place of two machines.

The arrangement of the slotted plates and tables will admit of many changes in the way of fastening work, but whenever a continuous support is needed, or the space between the tables not required, an extra plate or filling piece is bolted between them, making one continuous bed or table of the length required.

The length of the stroke permits the use of the table at different points along the bed, and prevents the undue wear that might take place if used for a long time in one position.

Some of the advantages claimed for a movable cutting tool are, that the weight and friction of the sliding carriage or saddle is the same at all times, and does not increase with the weight of the work or length of machine bed. The work remains stationary and may be conveniently and securely fastened to the slotted plates or tables, so that the cutting tool, when planing large or heavy work, may operate at the same height or level as when used upon the medium and smaller pieces.

Two out of the many possible applications of this machine have been selected for illustration here. Fig. 2 shows the machine in position for planing the sides of a boring machine table *A*. This kind of work, as may be seen, is done at the same expense and convenience as though it were a flat plate. The table *A* can be of any length, and project downward into a pit, as shown by the dotted lines. As the work does not move, the operation is like any common planing, takes only one-half the usual time, and is done in a superior manner.

On the other table is shown a long bracket, *B*, mounted for planing. In this case, it may be observed, there is no change or adjustment of the machine required. The vertical surface for fastening is provided, so no angle-plate is wanted. The work can be fixed in a few minutes, and the cutting is done in a convenient plane.

Fig. 3 shows the machine doing several kinds of work, all of which could be *fastened at one time* if desired.

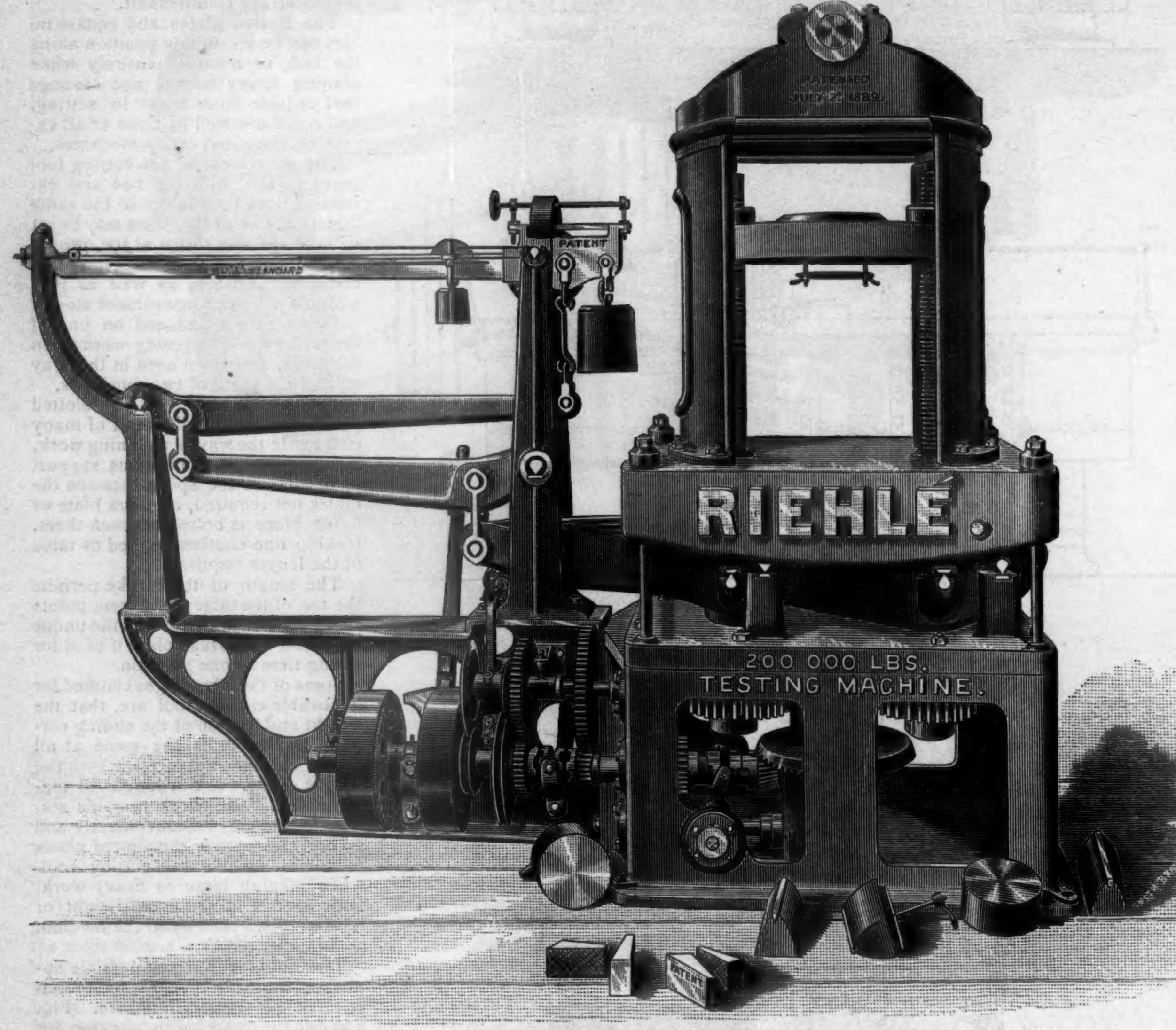
At *A* is a pipe flange being planed, the other end, of any length, extending into a pit, shown by dotted lines.

At *B* the foot of a diagonal brace is being planed, and at *G* the foot of a stand or column, which could be of any length.

Fig. 4 shows the machine planing the valve seat of a steam-engine cylinder *B*.

All the planing required for a steam-engine of 20-in. bore has been done on a machine of this kind. For some of the work the machine has had to be raised by putting blocks beneath; but, on the whole, the work was well and cheaply done.

None of the work above can be done conveniently on a common planing machine, while here, as before remarked, it is the same as planing flat plates.



RIEHLE VERTICAL 200,000 LBS. TESTING MACHINE.

Did space permit, many other illustrations could be given, such as planing valve-seats of large cylinders; planing sections of pulleys; machine frames; milling machine columns and similar pieces; lathe-beds; and generally pieces of difficult and unusual shapes. In fact, it seems difficult to find a limit to the range of work possible.

A number of these planers are in use, giving much satisfaction. They are made by the well-known firm of Pedrick & Ayer, of Philadelphia.

A Large Testing Machine.

THE accompanying illustration shows a Riehle patent vertical screw-power testing machine of 200,000 lbs. capacity. It is a well-designed and substantial machine, and in it are combined the latest improvements as to speed, etc.; it is also furnished with appliances for testing specimens by tensile, transverse, and compression strains. The total weight of the machine is a little over 10,000 lbs., and it is about 11 ft. long, 8 ft. high, and 4 ft. wide.

For tensile strains specimens from 8 in. to 24 in. in the clear length and of 2 in. in diameter and less can be tested. For transverse strains specimens can be made from 24 in. down to 12 in. or less in length, and by special appliances almost any reasonable length can be tested. The compression tools are of steel and are 8 in. in diameter. The motion of the head is 30 in. The machine has two adjusting speeds and six different speeds by which a specimen can be stretched or broken; also for driving in opposite directions. The maximum speed for testing and light tests—80 revolutions of pulley—is $5\frac{1}{4}$ in. per minute. There are a number of adjustments that can be arranged on this machine.

Strains from 10 lbs. up to 200,000 lbs. can be weighed, and by the use of the patent vernier poise all the weights can be reduced on the beam, or any part, as may be preferred. Many varieties of special forms of material can be tested very accurately, even though subjected to a very great strain.

In this machine there is applied the Riehle patented high-faced wedged grip, by the use of which it is claimed that flat specimens of material, such as boiler plate, etc., can be tested and without any tendency to tear from the edge. The high-faced wedges engage themselves first through the axial line of the specimen and from that line out; it is also claimed that this machine is so carefully designed and constructed as to be well adapted for the combination of high strains and very delicate work required of it. Machines of this kind are in use at the Navy Yard in Boston and at the Midvale Steel Works, in both places doing excellent work; the tests upon them are accepted by the Government as standard.

This machine is built by the well known firm of Riehle Brothers, in Philadelphia, who are owners of the patents covering the various features of its construction.

Bridges.

The contract for one mile of the elevated road in Sioux City, Ia., has been let to the King Iron Bridge & Manufacturing Company, of Cleveland, O., by the Sioux City Rapid Transit Company.

The Atlantic Coast Line has let the contract for the Contentnea draw-bridge to the Edge Moor Bridge Works. This bridge is a 145-ft. plate girder draw-span.

The Union Bridge Company has contracts for a number of bridges from the Queen & Crescent System and the Missouri, Kansas & Texas.

The Passaic Rolling Mills Company has built a number of plate girder bridges for the New York & Northern this season, and has recently received the contract for a sheer through span 67 ft. long, to be erected near Aqueduct station on that road.

The Union Bridge Company is pushing the work on the new eyebar plant. The building will be directly opposite the office at Athens and convenient to the present testing house and shipping-yard for eyebars. The eyebar plant from the Buffalo shops will be brought to Athens, and with their present plant there will be located in the new building. Both plants will be improved, and the combined output will probably much exceed the sum of the separate outputs hitherto. One of the features of the new plant will be the location of furnaces and an upsetting machine at each end of the building, thus avoiding the necessity of running the bars outside and turning them round. The combined plant will require considerable improvement, and the addition of a number of large dies, in order to manufacture the eyebars required for the Memphis Bridge, among which are bars 10 in. × 2¼ in. It is planned that the plant shall have the greatest capacity in the country, and shall be thoroughly equipped to manufacture the largest bars with the best attainable results.

The Boston & Maine Railroad has let the contract for an iron bridge of three 123-ft. spans in East Boston to the Boston Bridge Works.

The Springfield Improvement by the Boston and Albany Railroad is now practically complete. This has comprised two handsome depot buildings and the elevation of tracks and depression of Main Street to secure an overhead crossing.

The Ohio & Mississippi Railroad has let the contract for the White River bridge to the Union Bridge Company. It will be manufactured at Buffalo, and comprises three 150-ft. spans.

The erection of the Susquehanna Highway bridge, at Harrisburg, Pa., is progressing rapidly. The bridge comprises 12 spans of 175 ft. each, and two of 250 ft. each. Dean & Westbrook are the contractors, the shop work being sub-let to the Phœnix Iron Company.

The Shiffler Bridge Company has been organized in Pittsburgh with J. W. Walker, President; F. L. Geist, Vice-President and Treasurer; Charles D. Marshall, Secretary. The new company takes the Shiffler Bridge Works, heretofore owned and operated by J. W. Walker.

The Phœnix Iron Company has commenced to manufacture the iron and steel for the new Louisville bridge.

The three bridges built by the Pencoyd Bridge Company to cross the Schuykill River, about seven miles above Philadelphia, are rapidly approaching completion. All three are nominally for the Philadelphia & Reading Railroad, though that nearest Philadelphia is much more in the interest of the Baltimore & Ohio. This comprises one masonry and seven plate-girder spans. It practically joins the present West Falls Bridge at the Eastern end and curves South, thus avoiding the Y now used by the Baltimore & Ohio through trains. It is expected that trains may be run over it early in March. The next bridge is about one mile up the river, and has four deck-spans of lattice girders. It is a comparatively high bridge, and does not connect with the main line, but makes an overhead crossing. The third is just above the Pencoyd shops, and will connect the Norristown Branch of the Reading with the Pencoyd yards and the main line. It is a lattice girder bridge of four deck-spans.

The contract for the proposed elevated road in Sioux City, Ia., has been let to the King Iron Bridge & Manufacturing Company, of Cleveland, O.

The iron work for the bridge across the Ohio at Louisville is now in the shops of the Phœnix Bridge Company. Work on the foundations is rapidly approaching completion.

The Lake Shore & Michigan Southern Railroad contemplates extensive bridge work during the coming season. Most of this will be necessitated by the double-tracking of the entire line, which has already been begun. Two contracts have been let to the Union Bridge Company, a 300-ft. draw-span at Cleveland and a bridge of three 150-ft. through spans at Grand Rapids. Both are being built by the Buffalo shops, with the exception of the drum and track circle for the draw-span, which are being built by the Athens shop.

Manufacturing Notes.

The Strong Locomotive Works are to be built between Sharon and Glendale, near Cincinnati, where the Company has purchased a track of 1,350 acres of land, on which it will build not only the works themselves, but houses for the men employed, the purpose being to establish a town somewhat after the manner of Coleman. The works will be very extensive, and will have a capacity of one locomotive per day. It is proposed to build not only the Strong locomotive, but others of ordinary pattern, as may be ordered.

The Dunham Manufacturing Company, Chicago, together with the National Hollow Brake Beam Company, removed April 1 to their new and commodious quarters, 703–707 Phœnix Building. This change has been made necessary in order to accommodate their rapidly-increasing business, and the new location will give them about double the space now occupied in the previous offices in addition to affording superior light and ventilation.

The shops of Pedrick & Ayer, in Philadelphia, are being enlarged by the addition of two stories, the full size of the building, about 60 × 100 ft. This will nearly double their capacity, and has been made necessary by the increase of business, although the firm only moved into the present building a year ago.

The new steel boat for the New York Fire Department built by the Jonson Foundry & Machine Company, New York, was launched April 5. The *New Yorker*, as she is called, is 125 ft. 5 in. long, 26 ft. beam, and has a displacement of 350 tons. Her machinery consists of a triple expansion engine, built by Brown & Miller, of the Vulcan Engine & Boiler Works, Jersey City, with cylinders 15 in., 24 in. and 39 in. in diameter and 24 in. stroke. Her motive power will be generated by two steel boilers of the Scotch type 12 ft. in diameter and 13 ft. long, which are now building by McNeill & McLaughlin, of the Franklin Boiler Works, Greenpoint, L. I. These boilers will be supplied with four 38-in. patent corrugated furnaces, made by the Continental Iron Works, of Brooklyn. Her propeller consists of a four-bladed sectional wheel supplemented with a Kunstadter patent swiveling wheel, which is fitted to the main shaft abaft the rudder. Her four sets of fire pumps, of special pattern, are being built, two sets by Clapp & Jones, of Hudson, N. Y., and two sets by the La France Engine Company, of Elmira, N. Y.

OBITUARY.

William Galloway, the oldest locomotive engineer in the world, died in Baltimore, April 7, of apoplexy, aged 81 years. He had been in the employ of the Baltimore & Ohio Railroad 54 years, and only two years ago was retired on a pension.

William Loughridge died in Philadelphia, March 21, aged 74 years. Mr. Loughridge resided for many years in Washington and afterward in Baltimore, and was the inventor of the brake known by his name and of many other devices. His brake was one of the first attempts at the use of power brakes on railroads in this country, and was tested by him on the Baltimore & Ohio Railroad, the experiments extending over several years. It has not, however, come into general use.

John C. Campbell died in New York, March 26, aged 72 years. He was born in Cherry Valley, N. Y., and studied engineering, his first work of importance being on the Croton Reservoir under Mr. Jervis. Later he located and built a portion of the Hudson River Railroad, and in 1850 he went to Panama, where he superintended the building of the western half of the Panama Railroad. He was afterward employed in the construction and management of railroads in Indiana and Wisconsin for several years. On returning to New York he was appointed Chief Engineer of the Croton Aqueduct, and was subsequently Chief Engineer of the Department of Public Works of New York City for a number of years. He also acted as Consulting Engineer on some important water-works in Cali-

fornia. Mr. Campbell was a high authority on hydraulic engineering and the construction of water-works. For some time past he has been in failing health and has done no active work.

ALEXANDER L. CRAWFORD, who died in New Castle, Pa., April 1, aged 76 years, was one of the first who introduced iron manufacture in the Shenango Valley in Pennsylvania, having settled in that region in 1835 and built a blast-furnace and shortly after a rolling-mill. He continued in the iron business until his death. He was the principal builder of the New Castle & Beaver Valley Railroad, and was also largely interested in the St. Louis, Salem & Little Rock Railroad in Missouri, and the Nashville & Knoxville Railroad in Tennessee. He also owned iron and coal mines in Kentucky and in the Lake Superior regions.

T. G. HALSKE, of the well-known firm of Siemens & Halske, died in Berlin, Germany, March 17, aged 76 years. A native of Hamburg, he went to Berlin as a mechanic, and as early as 1844 set up a small mechanical shop there. Soon after this Mr. Werner Siemens made his acquaintance, and there, in Halske's workshop and assisted by Halske's remarkable practical skill, was enabled to experiment on and prepare for public exhibition his first inventions in the telegraphic line. In 1847 Siemens and Halske joined company in establishing a Telegraphic Institution which has since spread into those large works at Berlin, Charlottenburg, and elsewhere, which give employment to thousands of workmen, and the productions of which have carried the name and the fame of Siemens & Halske all round the globe.

FREDERICK GRAFF died suddenly in Philadelphia, March 30, aged 72 years. He was a son of Frederick Graff, Engineer of the Fairmount Water-Works, and was educated as a civil engineer. He served for several years as assistant to his father, and in 1847 succeeded him as Superintendent and Chief Engineer, holding that office until 1873 with the exception of the three years from 1853 to 1856, when he was out of office. In 1873 he retired from active work in his profession, but was engaged with many organizations and public bodies in Philadelphia, and was one of the best known citizens of that city. In 1880–81 he was President of the Engineers' Club of Philadelphia, and in 1885–86 he was President of the American Society of Civil Engineers. Although retired from office, he continued to act as consulting engineer, and his last professional service was as one of the Board of Engineers appointed by the United States Government to examine and report upon the Washington Aqueduct Tunnel.

PERSONALS.

W. F. HENDERSON has been appointed Master Mechanic of the Fort Worth & Denver Railroad, with office at Fort Worth, Tex., succeeding JOHN F. WHITE, who has resigned.

WILLIAM KENT, well known as a consulting engineer, now has his office at Room 125, *Times* Building, New York. Mr. Kent is now the representative in New York of the Pittsburgh Testing Laboratory of Hunt & Clapp.

F. W. D. HOLBROOK has resigned his position as Manager of the Seattle, Lake Shore & Eastern Railroad, and the position has been abolished. Mr. Holbrook will probably be engaged in the construction of the new extension of the road.

D. E. HERVEY is now Associate Editor of *Electric Power*. He is a gentleman of long experience in editorial work, and will make his training and ability felt in the columns of our excellent contemporary, which already stands high among the journals in its field.

W. F. ELLIS has resigned his office as Roadmaster of the New York, Providence & Boston Railroad, and has accepted a position with the Dunham Manufacturing Company, which he will represent in the interest of the Servis tie-plate and the Davies spike.

S. T. WAGNER, Superintendent of the Phœnix Iron Company, will go out in the field in charge of the erection of the Ohio River Bridge between Louisville and Jeffersonville, now being built by this Company. Mr. Wagner's health has been poor for some time past, and he hopes to benefit it by field work.

H. B. STONE has resigned his position as Second Vice-President of the Chicago, Burlington & Quincy Railroad Company, to become President of the Chicago and the Central Telephone companies. Mr. Stone has been some 12 years on the Chicago, Burlington & Quincy, serving as Superintendent of Motive Power, General Manager and Vice-President.

MARSHALL M. KIRKMAN, Second Vice-President of the Chicago & Northwestern Company; STUYVESANT FISH, President of the Illinois Central; J. C. PEASLEY, Vice-President of the Chicago, Burlington & Quincy; CHARLES C. WHEELER, a railroad officer of long service and high reputation; and J. T. JEFFREY, recently General Manager ot the Illinois Central, have been appointed directors of the International Exposition in Chicago.

THE following changes in stations and duties of the Corps of Engineers are announced: MAJOR CHARLES W. RAYMOND relieves CAPTAIN EDWARD MCGUIRE, who proceeds to Louisville, Ky., taking charge of the work heretofore under MAJOR AMOS STICKNEY. The last-named officer is transferred to Buffalo, N. Y., where he relieves CAPTAIN FREDERICK A. MAHAN, who is assigned to duty as Engineer of the Fourth Light-house District, in place of Major Raymond. FIRST LIEUTENANT JAMES C. SANFORD has been transferred from New York to St. Louis, where he will act as Secretary and Disbursing Officer of the Mississippi River Commission.

PROCEEDINGS OF SOCIETIES.

General Time Convention.—The spring meeting was held in New York, April 8. The President, Mr. H. S. Haines, made an address on the Question of Existing Relations between Railroad Companies and Labor Unions, and treating also of other matters.

The Committee on Standard Code of Train Rules reported that the code was now used by 93 companies operating 65,734 miles of railroad, an increase of 14 companies and 13,467 miles since the October meeting.

The Car Service Committee recommended that no definite action should be taken until the fall meeting upon recommendation to substitute a mixed mileage and per diem rate of payment for car service for the old mileage rate. This was adopted.

The following officers were elected for the ensuing year: President, H. S. Haines; Vice-Presidents, James McCrea and J. F. Royce; Secretary, W. F. Allen; Members of Executive Committee, H. Stanley Goodwin and J. G. Metcalfe; Members of Committee on Train Rules, J. T. Harahan and H. Walters.

It was decided to hold the next meeting in New York on the second Wednesday of October.

Master Mechanics' Association.—The Secretary has issued a circular stating that it will not be possible to hold the Convention in June at Chattanooga, as the Lookout Mountain Hotel will not be completed in time. As Buffalo and Montreal, the other places indicated for the Convention, are distant from Old Point Comfort, where the Master Car-Builders will meet, it was deemed best to give members the opportunity to vote on a new place of meeting, and they have accordingly voted to hold the Convention at Old Point Comfort.

American Society of Civil Engineers.—At the regular meeting, April 2, it was announced that the Committee on Rail Sections was not discharged. The resolution providing for a special Committee on Units of Measurement was carried and that for a Committee on Sewer Nomenclature was lost. The death of Frederick Graff, past President of the Society, was announced.

F. W. Watkins read a paper on Tunneling Surveying on Division No. 6, Croton Aqueduct, which was discussed by several members who had had experience in the work.

The tellers announced the following candidates elected:

Members: James H. Covode, Chili, South America; George S. Davison, Pittsburgh, Pa.; Lieutenant-Colonel Peter C. Haines, U. S. Eng., Washington; Alexander W. Jardine, Queensland, Australia; Thomas McCann, Hoboken, N. J.; Gaylord Thompson, Yonkers, N. Y.

Associate: Lewis R. Pomeroy, New York.

Juniors: Charles W. McMeekin, Des Moines, Ia.; Robert W. Creuzbaur, New York.

AT the regular meeting, April 5, the Secretary reported the special meetings of the Board of Directors and past officers, and the action taken at these meetings on the death of Mr. Frederick Graff. The report and minutes were adopted and remarks were made on the character of Mr. Graff.

The Secretary presented for Mr. Frank Cooper notes on Railroad Engineering Drawing, which were discussed by members present. Mr. E. H. Brown stated that he used no tracings, but had blue prints made directly from the finished drawings.

Mr. Edwin S. Crawley described a new form of Steam Valve in which packing is used instead of the ground seat. He exhibited a model and drawings. There was some discussion by members present.

AT the regular meeting, April 16, a paper by Mr. William Metcalf on Tests of Steel Bands was read and discussed.

Mr. John Bogart read a paper on the Results of Some Tests of Cements, which called out a long discussion.

THE annual Convention for 1890 will be held at Cresson, Pa., on the western slope of the Allegheny Mountains. The date will be near the end of June. The exact date and details will be announced in a later circular.

Boston Society of Civil Engineers.—At the annual meeting in Boston, March 19, David A. Harrington, John L. Howard, Clarence A. Perkins and Frank H. Snow were elected members.

The annual reports of the officers were presented and accepted. The permanent fund now amounts to over $3,000. The reports of the special committees were presented, and their discussion postponed to the next meeting.

Officers were then elected for the following year as follows: President, Clemens Herschel; Vice-President, J. R. Freeman; Secretary, S. E. Tinkham; Treasurer, Henry Manley; Librarian, F. W. Hodgdon; Director, F. Brooks.

Mr. Cope Whitehouse delivered an address upon Irrigation in Egypt, which was illustrated by maps and photographs.

Civil Engineers' Club of Cleveland.—At the annual meeting in Cleveland, March 11, the reports of the officers were presented and accepted. The standing Committees on Civil Engineering and Surveying, on Railroad Engineering, on Architecture and on Mechanical Engineering presented their yearly reports, which were read and accepted.

The following officers were elected for the ensuing year: President, W. H. Searles; Vice-President, J. L. Gobeille; Secretary, C. O. Palmer; Corresponding Secretary, S. J. Baker; Treasurer, N. P. Bowler; Librarian, C. N. Barber; Member of Board of Managers of the Association of Engineering Societies, Professor Cady Staley.

AT the regular meeting in Cleveland, O., April 8, H. F. Coleman was elected a member. The President made some remarks relative to the present condition of the Club and the necessity for better quarters.

In accordance with votes of the Club, the following committees were appointed: To confer with the Committee of the American Society of Civil Engineers on Affiliation between the Societies: A. Mordecai, J. Whitelaw, J. F. Holloway, W. R. Warner, H. C. Thompson.

To confer with the Cleveland Architectural Club in relation to the Joint Use of Rooms: Messrs. Barber, Staley and Palmer.

To carry out suggestions made by the President on the question of Increased Facilities for the Club: W. R. Warner, S. F. Wellman, W. Chisholm, H. S. Claflen and James Barnett.

Mr. Whitney, of the Pratt & Whitney Company, Hartford, Conn., by invitation made a short address to the Club.

Mr. Ambrose Swasey read a paper on the Eiffel Tower, which was illustrated by a number of diagrams and a large model of the tower. This paper was discussed by the members present.

Engineers' Club of Cincinnati.—At the February meeting Charles H. Meeds was elected a member and several applications were received. A budget of short papers by various members was read, the subjects chosen being:

1. Some Curiosities of our State Boundaries.
2. Turn-Outs.
3. Phonography as an Aid to Engineers.
4. Elevation of Outer Rail on Curved Trestles.
5. A Method of Pile Driving under Special Conditions.
6. A Plea for a Natural Motor.

New England Railroad Club.—At the regular monthly meeting in Boston, April 9, the subject for discussion was Locomotive Boilers. Mr. H. L. Leach read a carefully studied paper on Boiler Construction, describing present practice and outlining the best practice as proved by experience. He also discussed the question of steel and iron for boilers, and said that there were some boilers in use in New England that are over 30 years old and good yet. The discussion was continued by Messrs. Lauder and other members.

Western Railroad Club.—At the regular meeting in Chicago, April 15, the subjects for discussion were Counterbalancing Locomotives; the Master Car-Builders' Interchange Rules, and Journal-Boxes.

This Club has resolved to publish hereafter its proceedings in pamphlet form, and has requested the various technical journals to give no account of the discussions prior to the official publication.

Western Society of Engineers.—At the regular meeting in Chicago, April 2, Mr. Jenison explained his plans for a World's Fair building.

The Chicago Railroad Problem was discussed at length by Messrs. J. F. Wallace, Isham Randolph, H. C. Alexander, President Cooley and others, in relation to terminals, rapid transit and street crossing accidents. The opinion was expressed by several members that the Society ought to formulate a plan and submit it for public discussion. The subject was continued to the next meeting.

Tacoma Society of Civil Engineers & Architects.—At a special meeting in Tacoma, Wash., March 7, a paper was read by E. S. Alexander on the Water Supply of the city of Tacoma. This was followed by a discussion which showed that an excellent supply could be obtained from the adjacent streams without using Green River, the supply from which was not pure.

AT the regular meeting, March 21, a paper on the Preservation of Wooden Piles by Colin McIntosh was read. Specimens were shown of piles broken off 40 ft. below low water, upon which the bark was still preserved, but the body of the pile had been completely destroyed in the four months by the teredo. A specimen was shown of a strip of pile, which had been protected by creosoted strips of wood nailed to it. Another plan proposed was to first cut slabs from the pile which is then sheathed with three-ply building paper and the slabs afterward nailed on to protect the paper.

Papers on Street Improvements were read by D. B. Ogden and C. B. Talbot, advocating plans for paving, etc., which were thoroughly discussed by members present.

Engineering Association of the Southwest.—The regular meeting was held in Louisville, Ky., April 11, with a large attendance. Addresses of welcome were made by Louisville engineers. The following elections were announced:

Members: Robert L. Engle, Graham Macfarlane, Harry P. McDonald, Louisville, Ky.; Thomas Sharpe, Nashville, Tenn.

Associates: Lewis Collins, Udolpho Sneed, James B. Speed, Louisville, Ky.

A communication from the American Society of Civil Engineers relating to affiliation with local societies was referred to the Executive Committee.

Mr. Charles Hermany, Chief Engineer of the Louisville Water Company, read a paper on Excavating under Pneumatic Pressure, which, besides giving a general account of the different methods used, gave a description of the O'Connor Excavating Bucket, which was used in sinking the large caisson for the foundations of the new pumping stations in the Ohio River at Louisville.

Mr. Robert L. Engle read a paper describing the foundations of the Louisville & Jeffersonville Bridge, now under construction over the Ohio River. This was followed by a discussion, and at its close Messrs. O. H. Landreth, W. L. Dudley and G. W. Shaw were appointed a Committee to report on the present state of knowledge relating to the cost of the setting of cements and mortars.

On the day following the meeting the members of the Association made by invitation a trip over the Louisville Southern Railroad, inspecting the new bridge at Tyrone, and also visited the Louisville Water-Works and the works in progress on the Louisville & Jeffersonville Bridge.

NOTES AND NEWS.

Steatite Paint.—The use of steatite or soapstone, as the basis of an anti-corrosive paint, was advocated in a paper read at the meeting of the Institution of Naval Architects. It was said that it will not mix properly or dry with linseed-oil, dryers, turpentine, etc., but it has been embodied as a pigment or paint

with a quick-drying varnish, and as an anti-corrosive it was a success.

Adams's Exhaust-Pipe.—Figs. 1 and 2 represent longitudinal and transverse sections of Adams's "vortex" blast-pipe, which is the invention of Mr. W. Adams, Locomotive Superintendent of the London & Southwestern Railway. The main object of this invention is to equalize the draft through the tubes of the locomotive and thus to prevent the destructive action of the blast, which, with ordinary blast-pipes, acts with too great intensity through the upper rows of tubes. To overcome this Mr. Adams makes the exhaust orifice *A A* of annular form, shown clearly in the plan below fig. 2. The lower part of the exhaust-pipe is made of a bifurcated form, somewhat like a pair of trousers, the two legs or branches *B B* being attached to the exhaust-pipes *E E*. The branches *B B* have an opening, *F*, between them, and unite in the annular opening *C C* above the partitions *D D*, shown by dotted lines in fig. 2 and black shading in fig. 1. Inside of the annular nozzle *A A* there is a cylindrical central passage, *G*, which communicates directly with the opening *F*. When steam escapes from the opening *A A* it draws the air with it on the outside of the exhaust-pipe *P P* and of the escaping current of steam. It also creates a partial vacuum in the central passage *G*, which draws air from the opening *F*, and from the lower part of the smoke-box and lower rows of tubes. In this way the draft in the upper and lower tubes is equalized, which, it is said, results in a material economy in fuel consumption.

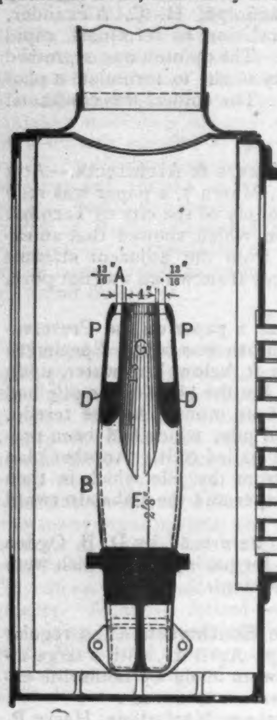


Fig. 1.

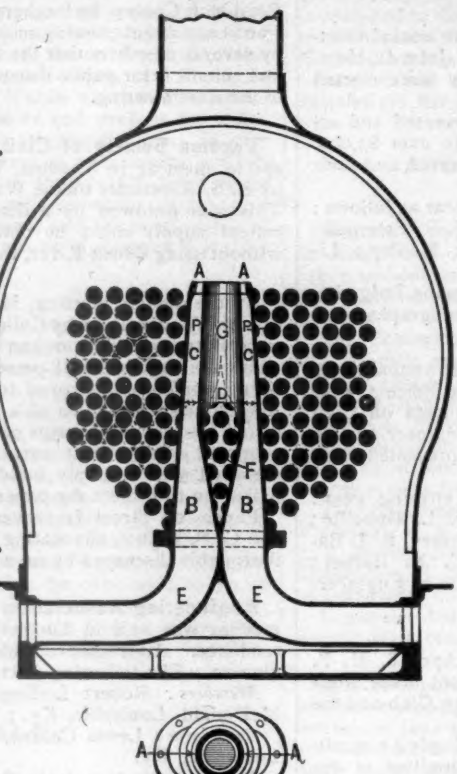


Fig. 2.

Extension Rails for Turn-Tables.—*Engineering* for April 4 contains an illustration and description of an arrangement of extension rails for lengthening turn-tables, which are too short for the "bogie" engines which are coming into use more and more in England. These rails are made to extend beyond the edge of the turn-table when it requires to be lengthened out. They are of an inverted ∩ section, and rest on top of the rails on the table when in use. The outer ends of the extension rails must be elevated to clear the coping of the turn-table pit. Consequently they are made so as to form an inclined plane from the fixed rails. From the engravings it appears that after the engine is turned it would have to be backed off of these extension rails, which can then easily be moved by the mechanism provided so as to lie parallel to and within the fixed rails. The engine can then be run off of the turn-table. This arrangement offers a cheap and ready means of adapting old turn-tables to modern requirements.

The Rule of the Road at Sea.—At the annual meeting of the British Institution of Naval Architects which has just been held, a paper on the recent Washington Maritime Conference was read by Admiral Colomb. This paper, *Nature* says, "was practically reduced to a consideration of the rule of the road at sea. The general opinion of the authorities assembled appeared to be that the present rule of the road is very well as it stands, with the exception that the 'holding-on ship' should not be required, or even allowed, to slacken her speed. This seems in conformity with common-sense. If two ships are converging toward a point, say at right angles to each other, and one shifts her helm to go under the other's stern, if the second, or holding-on ship, slacken speed, the probability will be that the giving-way ship will crash into the other's broadside or cross her bows; in the latter case, there is probability that the holding-on ship will give the other her stem. What is most wanted when danger of collision arises, is certainty on each vessel as to what the other may be going to do. If the holding-on ship never slacken speed—is not allowed to slacken speed—then the other vessel knows exactly what course to take; as the law stands, the quartermaster, or officer in charge, is never quite sure until the last minute, especially at night, whether the other ship considers there is danger of collision or not, and, therefore, whether she will slacken or keep to full speed."

Boilers with Weldless Rings.—A correspondent of the London *Engineer* writes to that paper—Sir Joseph Whitworth & Company have in contemplation the erection of additional works in the neighborhood of the Manchester Ship Canal, where they propose introducing an important departure from the present practice in the erection of marine and other boilers. It will be remembered, at the recent Manchester Exhibition the above firm exhibited a weldless boiler ring, 12 ft. diameter by 6 ft. long, which at the time attracted very considerable attention; and at their new works it is their intention to lay down plant for the construction of boilers built up of weldless rings, for which it is claimed that while they reduce the weight of the boiler by 30 per cent., it is at the same time kept up to its full strength. So far, no marine boilers have been constructed on this principle, but that there is no difficulty in the manufacture of these weldless boiler shells for the above purpose has been evidenced by what Sir Joseph Whitworth & Company have already accomplished. In some instances these shells would go up to 14 ft. diameter, and the practically insurmountable difficulty of conveying such large pieces of work either by rail or road renders it, of course, necessary that works for their manufacture should be placed at the water side.

The Largest Gun.—The largest gun yet manufactured was recently completed at the Krupp Works in Essen, Germany, for the fortifications at Cronstadt in Russia. It is of the finest quality of steel and weighs 135 tons; the caliber is 16¼ in., and the total length 44 ft. The greatest diameter, over the outside rings, is 6 ft. 6 in. The estimated range is about 12 miles. Each shot fired from this gun costs about $1,500. At the trial of the gun, the projectile, 4 ft. long and weighing 2,600 lbs., was propelled by a charge of 700 lbs. of powder and penetrated 19 in. of armor, going 1,312 yards beyond the target. It was carried from Essen to Hamburg on a car specially constructed for the purpose. Work is reported as now being pushed forward on several guns of this class.

Export of Scotch Locomotives.—During the first three months of this year there were exported from Scotland locomotives of a total value of £90,469 against a quarterly average of £90,000 last year and of £71,000 in 1888. The value of those shipped during the first quarter of this year to the Continent was £50,000, and those to Australasia £14,000.

Petroleum in Roumania.—The richest petroleum districts in Roumania are situated southeast of the Carpathian Mountains. In many places in this district, especially at Ploiesti, the ground is charged with gas to such a degree that it is only necessary to bore a hole and a jet of inflammable gas issues at once. The wells here are in general from 160 ft. to 230 ft. deep, though some are as much as 400 ft. in depth, and still deeper borings are now being put down.